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Forest Service

**Pacific
Northwest
Region**

Western Spruce Budworm Management in Oregon & Washington during 1988

Environmental Assessment

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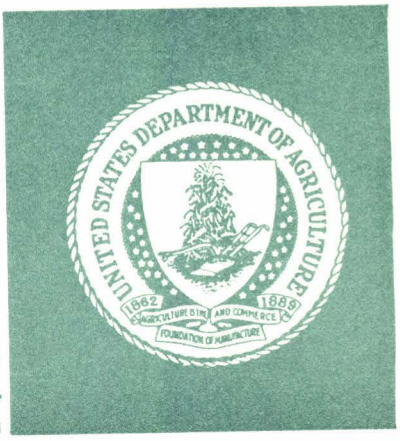

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TABLE OF CONTENTS

PAGE

I. PURPOSE AND NEED FOR ACTION---------- 1

A. Introduction---------- 1
B. Background---------- 1
1. The Situation---------- 1
2. The Insect---------- 4
3. History of Western Spruce Budworm Control in Oregon and Washington---------- 7
4. Major Issues and Concerns---------- 12
C. USDA Forest Service Participation---------- 15
1. Statutory Authority and Direction---------- 15
2. Agency Goals---------- 17

II. ALTERNATIVES---------- 19

A. Introduction---------- 19
B. Background Information---------- 19
1. Size of the Area to be Analyzed---------- 19
2. Timing of the Analysis and Decision Implementation---------- 20
3. Time Scope of the Analysis---------- 21
4. Insect Pests to be Analyzed---------- 22
5. Division of the Area for Analysis---------- 22
C. Alternatives Considered but Eliminated from Further Study---------- 23
1. Direct Suppression using Chemical Insecticides---------- 23
2. Suppression using Silvicultural Management Techniques---------- 23
3. Suppression using Biological Methods Other than B.t.---------- 23
D. Alternatives Considered and Studied in Detail---------- 23
1. Alternative 1 - No Action---------- 23
2. Alternative 2 - Direct Suppression with Biological Insecticide (B.t.)---------- 24
E. Comparison of Alternatives---------- 27

III. AFFECTED ENVIRONMENT ---------- 32

A. Host Vegetation---------- 32
B. Classified Streams, Watersheds, Floodplains and Wetlands---------- 32
C. Non-Target Organisms---------- 35
1. Terrestrial Wildlife and Domestic Livestock---------- 35
2. Aquatic Invertebrates and Fish---------- 39

IV. ENVIRONMENTAL CONSEQUENCES---------- 40

A. Introduction---------- 40
B. Consequences of Alternatives---------- 40
1. Potential Effects on Wood Fiber Production---------- 40
2. Potential Effects on Water Quantity and Quality---------- 45

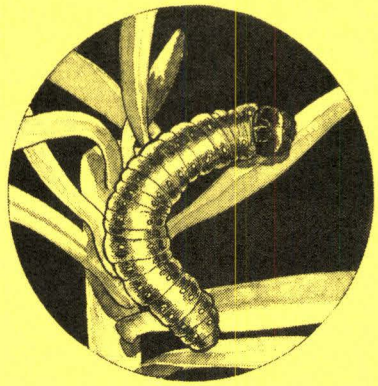
3. Potential Effects on Terrestrial Wildlife and Domestic Livestock---------- 47
4. Potential Effects on Aquatic Invertebrates and Fish--------- 52
5. Economic Efficiency and Local Economic Impacts---------- 54
6. Potential Human Health Hazards---------- 56
7. Uncertainties in Achieving Lasting Spruce Budworm Population Reductions---------- 60
8. Potential Effects on Threatened, Endangered, and Candidate Species---------- 63
9. Potential Effects on Cultural Resources---------- 64
10. Irreversible and Irretrievable Effects---------- 64
11. Short-Term Human Uses Affecting Long-Term Productivity---------- 65
12. Energy Requirements and Energy Conservation Potential---------- 65
13. Potential Effects on Wilderness Resources---------- 66
14. Potential Effects on Visual Resources---------- 66
15. Potential Effects on Classified Streams, Watersheds, Floodplains, and Wetlands---------- 66

C. Consequences Common to Both Alternatives---------- 67
1. Prime Farmland and Rangeland---------- 67
2. Social Factors---------- 67

V. CONSULTATION---------- 68
A. Public Involvement Process---------- 68
B. Individuals and Organizations Consulted---------- 69

VI. APPENDICES

A. List of Preparers---------- Appendix A
B. Pesticide Background Statement: Bacillus thuringiensis-- Appendix B
C. Western Spruce Budworm Economic Efficiency Analysis for Oregon and Washington, 1986---------- Appendix C
D. Maps of Analysis Units---------- Appendix D
E. Methods Used for Estimating Timber Volume Losses caused by a Western Spruce Budworm Outbreak---------- Appendix E
F. References Cited----------Appendix F



I. Purpose and need for action

I. PURPOSE AND NEED FOR ACTION

A. Introduction

In 1987, an Environmental Analysis and Assessment was conducted to evaluate the alternatives for managing the western spruce budworm outbreak on Federal, State, and adjacent privately owned lands in Oregon and Washington. The USDA Forest Service was the lead agency, and the USDI Bureau of Indian Affairs and USDI Bureau of Land Management, Oregon Department of Forestry, and Washington Department of Natural Resources were cooperating agencies. During the analysis, two alternatives were developed. These were: 1. No Action, and 2. Treatment with Bacillus thuringiensis (B.t.), a biological insecticide. In the Decision Notice, treatment with B.t. was the selected alternative for the Rimrock Analysis Unit on the Wenatchee National Forest in Washington and for several Analysis Units on the Malheur National Forest in Oregon. Treatment of these areas was implemented in June of 1987.

Since the alternatives being evaluated in detail are the same in 1988, it was decided that the 1987 Environmental Assessment would be updated to include current information. In addition, areas eliminated from detailed study and those analysis units with a benefit/cost ratio of less than 0.78 at the $11.45/acre treatment cost, four percent discount rate, and one percent real stumpage price increase in the 1987 document would not be considered in further detail in 1988. Some newly infested areas not previously considered in an environmental analysis are being evaluated this year.

The current western spruce budworm outbreak now encompasses approximately 5.8 million acres and is expected to continue in size and intensity in 1988. There are 21 analysis units considered in this analysis.

B. Background

1. The Situation

The western spruce budworm, (Choristoneura occidentalis Freeman), is the most widely distributed and destructive defoliator of coniferous forests in western North America (Fellin and Dewey, 1982). The caterpillar (larval) stage of the insect is the destructive feeding stage; the adult is a small orange-brown mottled moth. Endemic to most fir stands, the insect's population levels are usually held in check by the interaction of parasites, predators, timber stand conditions, and weather. Periodically, for unexplained reasons, the complex of natural controls is no longer able to limit growth of budworm numbers and an outbreak occurs.

At epidemic levels, budworms may defoliate entire timber stands, feeding primarily upon new needle growth and affecting mostly Douglas-fir, grand fir, and white fir which are the preferred host species. Outbreaks typically last from 6 to 10 years, resulting in five types of damage to host trees: growth loss, top kill, deformity, reduced seed production, and mortality.

A major budworm outbreak, now in its seventh year, currently exists in northeastern Oregon, encompassing large parts of the Ochoco, Malheur, Umatilla, and Wallowa Whitman National Forests and adjacent State and privately owned lands. Budworm defoliation was first detected during the aerial survey of 1980 when 6,000 acres were mapped in the Mill Creek Drainage near Cove, Oregon. By late summer of 1981, the number of defoliated acres had risen to 300,000. An environmental analysis of the situation led to an insecticide spray project during the summer of 1982, when 178,549 acres were treated on the Malheur and Umatilla National Forests.

Although the control efforts were considered successful, the August 1982 aerial detection survey showed that the outbreak then covered 1.5 million defoliated acres, which was a substantial increase. Based on another analysis, it was decided to conduct a second control project, this time aerially treating 524,561 acres with insecticides on the same two Forests during the summer of 1983.

Although treatments were considered operationally effective on most of the area, the 1983 project was marred by a major accident. On June 13, a contractor's tank truck left the road, and approximately 1,900 gallons of Sevin 4-Oil mix was spilled into Willow Creek. This unfortunate occurrence, at the beginning of the project, set the scene for extensive media coverage of several subsequent mishaps.

The defoliated acreage increased to 2.4 million in 1983, prompting another analysis. No operational spray projects were conducted in 1984. However, a small 850-acre field test of the biological insecticide Bacillus thuringiensis (B.t.) was conducted on the Ochoco National Forest. In 1984, defoliation covered 2.9 million acres, prompting another analysis of the situation. The only budworm treatment carried out in 1985 was an operational evaluation of several formulations of B.t. on about 40,000 acres. Defoliated acres increased to 3.6 million in 1985. In 1985 and 1986, an analysis was again conducted, this time only considering the alternatives of no action and treatment with B.t. No treatment was done in 1986 due to the lack of suppression funds. The outbreak increased to 6 million acres in size in 1987. In 1987, 135,000 acres were treated on the Wenatchee and Malheur National Forests.

The last major budworm outbreak in northeast Oregon started in the 1940's and continued until the middle to late 1950's. The majority of the area was sprayed with insecticide between 1949 and 1958. Budworm defoliation was detected on the eastern edge of the Wallowa Whitman National Forest from 1970 to 1975; however this infestation was not considered major and was not treated with insecticides.

Though the current outbreak began in northeastern Oregon in 1980, western spruce budworm infestations have subsequently appeared in other parts of Oregon and Washington. Budworm defoliation in the current outbreak was first detected from the air on the east slope of the Cascade Mountain Range in Oregon in 1983. At that time, the infestation covered about 66,000 acres on the Mt. Hood National Forest, adjacent State and private lands, and the Warm Springs Indian Reservation. Defoliated acreage increased to

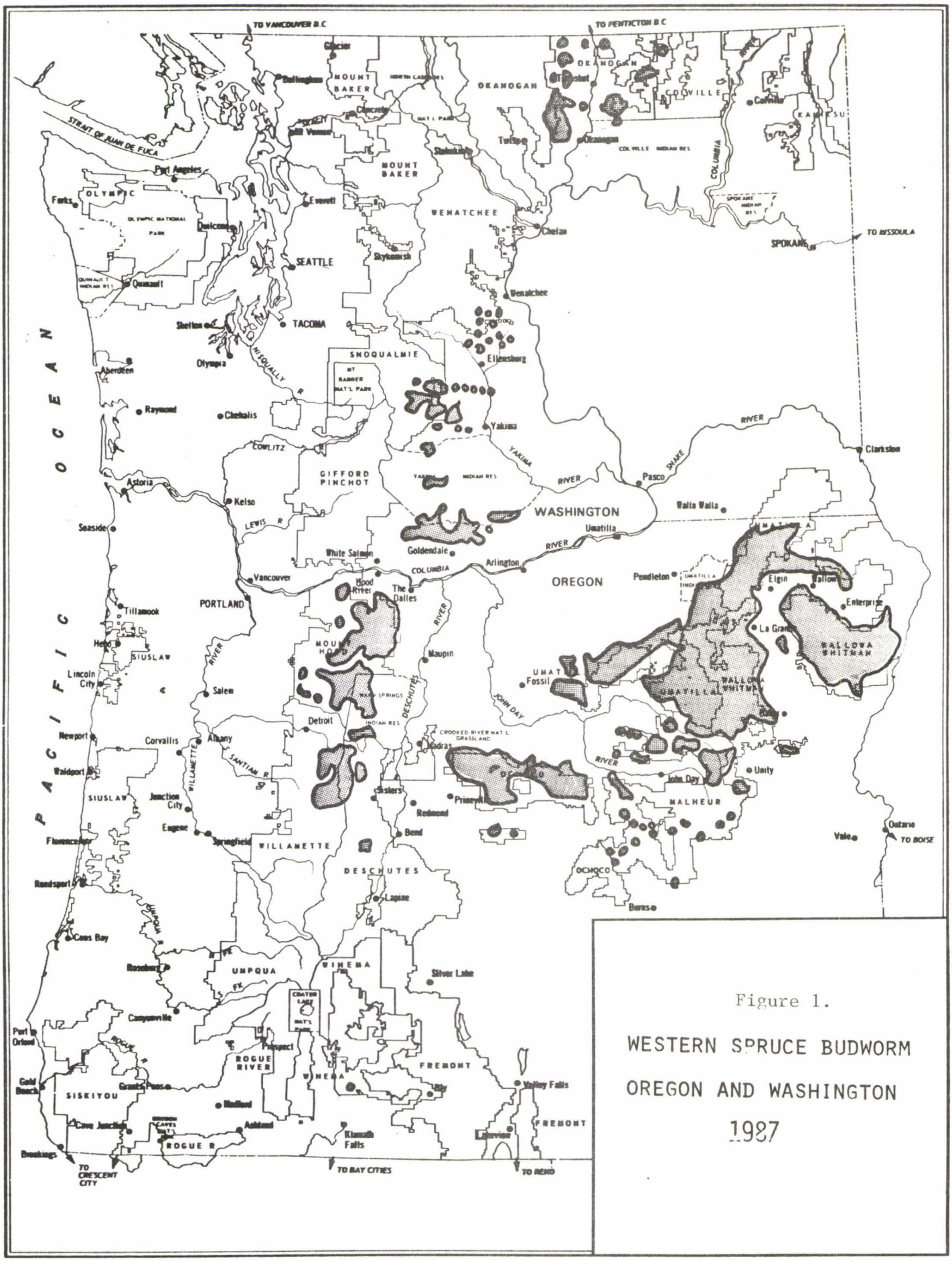


Figure 1.

WESTERN SPRUCE BUDWORM

OREGON AND WASHINGTON

1987

160,000 in 1984, including some acreage on the Deschutes National Forest. The apparent defoliation had increased to about 640,000 acres in 1985, and to about 910,000 acres in 1986. This is the first outbreak of comparable size on the eastern slope of the Oregon Cascade Range since the late 1940's. A smaller outbreak on the Warm Springs Indian Reservation, which started in 1974, was treated with a 34,000-acre insecticide spray project in 1979.

On the east side of the Cascade Range in Washington, western spruce budworm defoliation was first detected in 1970 on the Okanogan and Wenatchee National Forests. This outbreak increased to over 1 million acres in 1976 and 1977. Insecticide treatment was carried out in 1976 (358,000 acres) and 1977 (356,000 acres). The remaining untreated populations seemed to diminish significantly in 1978. Defoliation was again detectable in the original outbreak area by 1983. Different areas of defoliation began appearing in 1978 on and adjacent to the Tonasket Ranger District of the Okanogan National Forest, and have been detected to varying degrees since that time with 448,000 acres detected in 1986, including some previously treated areas.

On the Naches Ranger District (administered by the Wenatchee National Forest), 12,000 acres of budworm defoliation were mapped in 1984, 134,000 acres in 1985, and 80,610 acres in 1986. This is the first western spruce budworm defoliation to be reported in the area.

The most recent aerial detection survey, flown in the summer of 1987, and the subsequent egg mass and defoliation survey revealed that the epidemic budworm populations have not yet collapsed; the defoliated area now covers nearly 6 million acres in Oregon and Washington combined. This might seem to imply that the insect populations spread widely from a common geographic source. It is more a case, however, of endemic populations in various locations expanding simultaneously in response to favorable conditions, primarily related to weather. The infestation is located on lands of diverse ownership, having significant potential impacts on management objectives and practices of many private and public land managers alike. The general location of 1987 defoliation in Oregon and Washington is shown in Figure 1.

2. The Insect[1/]

The western spruce budworm (Choristoneura occidentalis Freeman), a native insect species, is one of the most widely distributed and most destructive pests of coniferous forests in North America. It is one of nearly a dozen

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1/ Unless otherwise cited, material is extracted from: Fellin, Shearer, and Carlson. 1983. Western spruce budworm in the northern Rocky Mountains: biology, ecology, and impacts. Western Wildlands. Montana Forest and Conservation Experiment Station. University of Montana. Missoula, Montana.

A synthesis of current knowledge about the insect and its hosts is in: Brookes, M.H., R.W. Campbell, J.J. Colbert, R.G. Mitchell and R.W. Stark Technical Coordinators. 1987. Western spruce budworm. Tech. Bull. 1694. USDA Forest Service. Washington, D.C. 198 p.

species, subspecies, or forms of a spruce budworm complex found throughout the western, north central, and northeastern United States and in several western and maritime Canadian provinces. The genus is also represented in Europe.

In Oregon and Washington, the budworm completes one cycle of development from egg to adult within 12 months (Figure 2). Following flight of the adults in late July and August, moths lay eggs that soon develop into tiny larvae which overwinter in an inactive state in sheltered places, under bark scales, and in or among lichens on tree boles or limbs. In early May to late June, larvae emerge and begin their active feeding stage. As rapidly growing larvae, spruce budworms molt (shed their skin) a total of five times. The six intervening stages are called instars. After about 30 to 40 days, larvae then develop into pupae. After about 10 days, the moths emerge from the pupae to begin the cycle again.

Within its range, the budworm infests forests in a variety of ecological situations: in pure and mixed stands on both poor and good sites, over wide topographic, physiographic, climatic, geographic, and elevational gradients, and in a variety of habitats. In Oregon and Washington, the vegetation zones affected are the Douglas-fir and true fir zones (Franklin and Dyrness 1973) and include the ponderosa pine/Douglas-fir co-climax, mixed conifer, white fir, and subalpine fir plant communities (Hall 1973). The budworm feeds on all age classes of host tree species.

The most common host tree species are Douglas-fir, grand fir, and white fir. Occasional host species include subalpine fir, Engelmann spruce, western larch, lodgepole pine, and ponderosa pine.

On most host tree species, western spruce budworm larvae feed as typical defoliators. Though preferring succulent new foliage, they also feed on older foliage when new foliage is in short supply or is not available. By the time larvae reach maturity in early to mid-July, they often have consumed or destroyed much of the new foliage on host trees.

Western spruce budworm larvae also feed on the cones and seeds of several species of host trees, particularly Douglas-fir (Dewey 1970) and western larch (Fellin and Shearar 1968).

Budworm populations are usually regulated by several natural factors such as parasites, predators, and adverse weather; especially when populations are low (Dewey 1974). Starvation can also be an important mortality factor in regulating populations during prolonged outbreaks. More than 40 species of budworm parasites are known which attack the host larval stage, but none has been found to have much effect on high budworm populations during an outbreak (Torgersen et al. 1984). Besides vertebrates such as squirrels, two of the most common predators are spiders and ants. Spiders may consume or kill large numbers of prey, such as dispersing or newly hatched larvae. Although ants may kill a large percentage of western spruce budworm pupae, the role of predaceous ants is not clear (Campbell and Torgersen 1983). Birds known to feed on the budworm include grosbeaks, warblers, thrushes, sparrows, flycatchers, tanagers, siskins,and waxwings (Fellin and Dewey 1982). Birds are usually not abundant enough to effect a significant decrease in the number of budworms, nor do pathogens appear to be an important factor in regulating western spruce budworm populations.

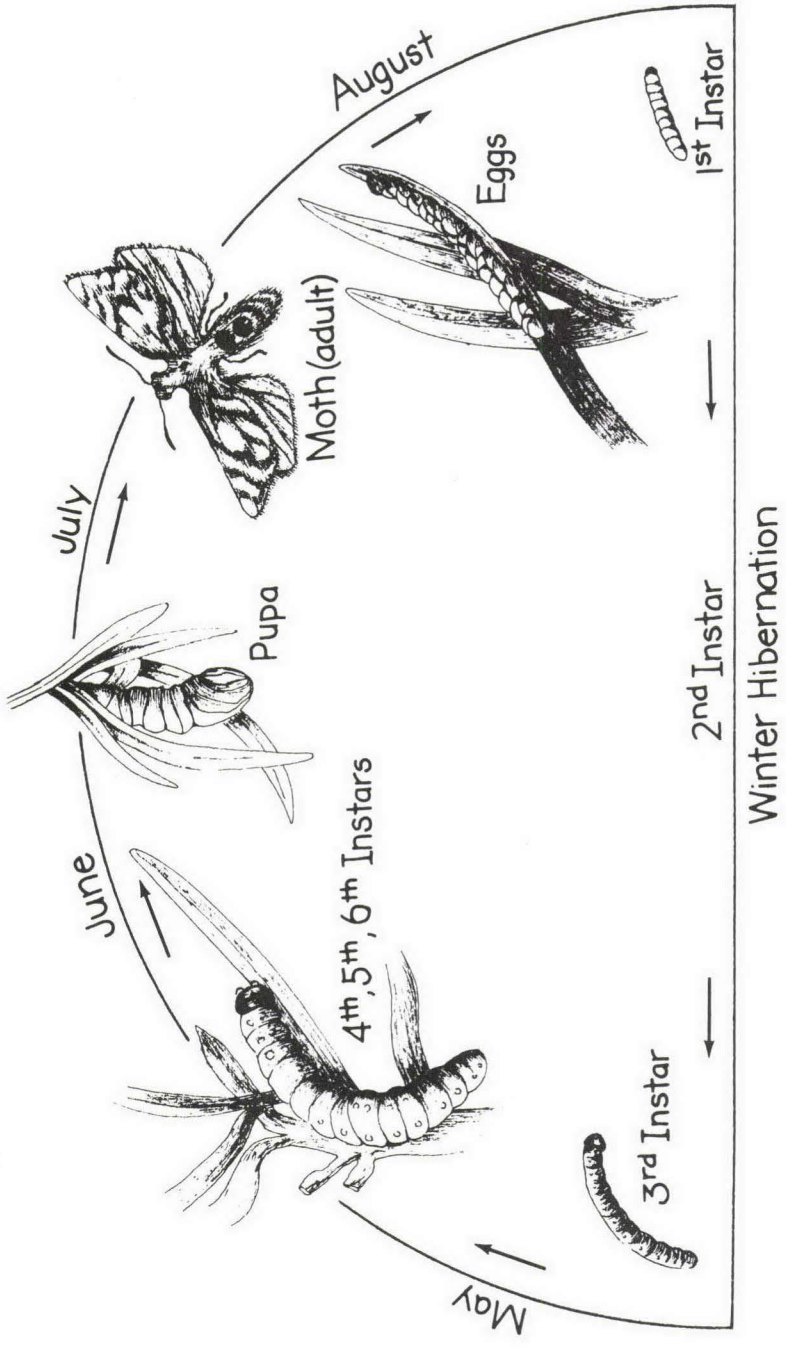


Figure 2. Life Cycle of the Western Spruce Budworm (Choristoneura occidentalis Freeman)

Studies in other areas indicate that weather may be the natural factor with the most dramatic effects on budworm populations. Small larvae hatching from eggs or disbursing from their overwintering sites may be blown from the host tree to the forest floor where they are often eaten by predators or die from exposure to sunlight or starvation. Cool summer weather retards feeding and development, increasing the time larvae are vulnerable to predators and parasites. Occasionally, larvae have not emerged from eggs before the first freezing temperatures in late summer and early fall. Collapse of populations has been suggested to occur because of exceptionally warm weather in the autumn. This results in the larvae remaining active rather than locating places where each can overwinter. Under these conditions, active larvae deplete their reserves of nutrients obtained from the egg. Without these reserves the majority of the larvae would starve during the winter and early spring before they could do serious damage to their host plants.

Conversely, it is also believed that favorable weather, such as late onset of fall freezing and warm spring and summer conditions, is a major contributor to population increases.

In smaller forest management units, the individual or combined effects of natural factors is probably responsible for the decline, termination, or pattern of western spruce budworm outbreaks. On the other hand, the ineffectiveness or absence of natural mortality factors is often responsible for population resurgences. Because the ecosystems of Oregon and Washington provide a variety of ideal habitats for the budworm, the combined effect of natural agents does not prevent or reduce population resurgences when climatic and forest stand conditions are favorable.

3. History of Western Spruce Budworm Control in Oregon and Washington

a. Outbreaks and Treatment Projects

Western spruce budworm was first recorded in the Pacific Northwest Region in 1914, when specimens were reared from Douglas-fir at Ashland, Oregon (Lindsten et al. 1949). Subsequently, budworm defoliation was noted in limited areas near Northport, Washington in 1928, in central Oregon near Mitchell in 1931, and in the Warner Mountains southeast of Lakeview, Oregon in 1932, 1941, and 1942 (Lindsten et al. 1949 and Carolin 1965). All of these outbreaks were small and subsided without causing appreciable timber loss.

In 1943, budworm defoliation was discovered in the Methow Valley on the Okanogan National Forest in north-central Washington. This infestation eventually developed into the first major recorded western spruce budworm outbreak in the Pacific Northwest Region. An estimated 200,000 acres were defoliated before the infestation collapsed from natural causes in 1948. In 1944, an infestation developed on the Umatilla National Forest in northeastern Oregon that eventually involved the entire fir host type throughout the Blue Mountains. A summary of western spruce budworm control projects conducted in Oregon and Washington from 1949 through 1987 is shown in Table 1. Dolph (1980) provides greater detail about both budworm activity and the control projects that occurred through 1979.

Table 1. Western Spruce Budworm Control Projects in Oregon and Washington From 1949 Through 1985

Thousands of Acres

Year	Oregon	Washington
1949[1/]	267.0	-
1950	907.4	25.9
1951	801.6	125.0
1952	529.6	134.6
1953	369.2	-
1954	67.7	-
1955	620.9	-
1958	818.0	-
1962	-	46.2
1976[2/]	6.9	351.1
1976[3/]	-	7.7
1977[3/]	0.7	356.0
1979[3/]	34.4	-
1982[3/]	69.3	-
1982[4/]	9.2	-
1983[3/]	02.0	-
1983[5/]	12.5	-
1983[6/]	10.1	-
1985[7/]	41.0	-
1987	94.0	44.1

1/ DDT used in all projects 1949 through 1962 (1 lb./gal.oil/A)
2/ Malathion ULV used (13 fl. oz./A)
3/ Sevin-4-Oil (carbaryl) used (1 lb./1/2gal. oil/A) 4/ Orthene (acephate) used (1/2 lb./1 gal. water/A)
5/ B.t used (12 BIU/3 qts. water/A)
6/ Zectran (mexacarbate) used (.15 lb./1gal. oil/A)
7/ Operational evaluation of five different B.t treatments

Since 1970, budworm activity has been concentrated in three areas of the Region: the east slope of the Washington Cascade Range, the east slope of the Oregon Cascade Range, and the Blue Mountains of northeastern Oregon. Table 2 shows the progression of an outbreak on the east slope of the Washington Cascades which started in the early 1970's. Insecticides were applied in 1976 and 1977 (Table 1) and the population declined to endemic levels by the early 1980's. Since that time, populations have started increasing again. South of the 1970's outbreak area, budworm populations increased and caused considerable defoliation in the Rimrock Lake area on the Wenatchee National Forest. This area was treated with insecticide in 1987.

A relatively small outbreak occurred on the east slope of the Oregon Cascades on the Warm Springs Indian Reservation in the mid to late 1970's. Tables 1 and 2 show that it began in 1974, insecticides were applied in 1976, 1977, and 1979, and the population collapsed in 1979. Populations in this area have again increased and are now at high levels.

A major budworm outbreak in the Blue Mountains of Oregon began in 1980 and is continuing (Table 2). Insecticides were applied in 1982, 1983, 1985, and 1987 to portions of the outbreak area (Table 1). During the 1985 aerial survey, defoliation was again detected over most of the area treated in 1982 and 1983.

Table 1 shows that a number of insecticides have been used since 1976. Recent evaluation has focused on the use of Bacillus thuringiensis, a microbial insecticide (Beckwith et al. 1984 and Ragenovich 1985).

Table 2. Area Visibly Defoliated by Western Spruce Budworm in Oregon and Washington 1970 Through 1986

	Thousands of Acres		
Year	NE Oregon (Blue Mtns.)	E Side OR Cascades	E Side WA Cascades
1970	14	-	0.2
1971	28	-	18
1972	23	-	202
1973	48	-	282
1974	2	7	564
1975	8	11	513
1976	0.4	11	1089
1977	-	19	1176
1978	-	6	193
1979	-	29	378
1980	6	-	127
1981	313	-	30
1982	1531	-	9
1983	2373	66	38
1984	2884	160	53[1/]
1985	3600	640	420
1986	4545	1024.3[2/]	448.2
1987	2875	913	466

1/ 12,000 acres defoliated near Rimrock Lake; first time budworm defoliation ever recorded in this area.

2/ On the west side of the Oregon Cascades (Willamette NF), 89,570 acres of visible defoliation were noted.

b. Results of Suppression Projects During the Current Outbreak

In the 1982 Budworm Suppression Project, budworm populations 14 days after treatment were below the target level of 7 larvae/100 buds in carbaryl-treated areas. Post-treatment populations averaging 9.1 larvae/100 buds in acephate-treated areas did not meet the targeted level

(Hostetler 1983). Since acephate is a water soluble formulation, rain showers within 1 day after treatment in some areas may have removed some of the toxicant from the target foliage. In other areas, where rain was not a factor, other conditions affecting the quality of spray application may have been responsible for the undesirable results.

Defoliation sampling within 1982 treatment units at many of the larval population sampling sites was conducted during 1983. In the carbaryl-treated units, the overall defoliation was light in one unit, light to moderate in two, and moderate in one. Defoliation in the acephate-treated unit was heavy. An untreated unit showed extremely heavy defoliation.

In the approximately 525,000 acres treated during 1983, larval sampling 2 to 3 weeks after insecticide application indicated that budworm populations were reduced to below targeted levels of 1.5 larvae per 45-cm branch tip on about 70 percent of the units treated (Bridgwater 1983). The 1.5 larvae per branch tip target equates to about 4.5 larvae per 100 buds--the unit of measure used in 1982. On the other 20 percent of the treatment units, while population levels were greatly reduced, they remained above targeted levels, ranging from 1.7 to 3.3 larvae per 45-cm branch tip. These higher levels may have been due to problems with application rather than insecticide ineffectiveness.

The 1987 suppression projects had mixed results. Of the three units treated (North and South Units on the Malheur National Forest and Rimrock on the Wenatchee National Forest), the Rimrock Unit was an unqualified success. On the Rimrock Unit, all of the contracted acreage (44,000) was treated, the population density was reduced to 0.89 $\pm$ 0.10 budworms per 45 cm branch tip, and spray deposit was acceptable. There were no application, administrative, or contractual problems of note.

The North and South Units on the Malheur National Forest will be discussed as one. Because of administrative and contractual problems, only 94,000 of the 204,000 acres originally contracted for were treated. Of those acres treated, 34,500 had budworm population densities reduced to 1.11 $\pm$ 0.19 budworms per 45 cm branch tip; barely meeting the threshold value of 1 larva per branch tip. Spray deposit was judged as marginally acceptable on those acres. The rest was considered as unacceptable.

Small ares on the Ochoco and Malheur National Forests were treated with B.t. in 1984 and 1985 to determine the cost-effectiveness of various formulations and application techniques. The 1984 test confirmed that 12 billion international units (BIU's) per acre is superior to 8 BIU's per acre, and that application with small helicopters using rotary atomizer spray nozzles which produce relatively small droplets (i.e., mass median diameters of 100 to 125 microns) is desirable. Population reduction to below 1.5 larvae per 45-cm branch tip was reached on about 75 percent of the treated plots (Beckwith, Stelzer, and Hostetler 1984). In 1985, the operational evaluation on the Malheur National Forest was conducted to determine if B.t. could reduce budworm populations to or below 1 larva or pupa per 45-cm branch tip. The evaluation was unable to discern significant differences among any of the treatments, all of which were successful. A helicopter application of Thuricide 32LV, 16 BIU's per acre,

applied at 64 fl. oz. per acre resulted in the lowest density of surviving larvae and pupae. This reduced survivors to 0.37 per 45-cm branch tip (Ragenovich 1986).

c. Accidents

During the 1983 budworm control project, five accidents occurred. Four involved spray helicopters, and the fifth involved a truck transporting insecticide to a helicopter batch site (USDA Forest Service, Pacific Northwest Region, 1984). One spill involving a helicopter occurred in 1985. No accidents occurred on either the Malheur or Rimrock projects in 1987.

The potential for accidents exists whenever aircraft are used to apply pesticides. Some types of incidents are within the control of project personnel while others are difficult to foresee and prevent. In general, there are three causes of accidents during a treatment project:

Mechanical Failure: Accidents resulting from mechanical failure can be from loss of power needed to maintain flight, loss of maneuverability, and malfunction of the mechanisms controlling the application of the pesticide, including those involved with the emergency release system. Many mechanical-failure accidents can be prevented by rigorous maintenance and routine inspections.

The types of accidents that are caused by mechanical failure include: damage to the aircraft and injury to the pilot resulting from a forced landing, unintentional activation of the emergency release system causing unplanned environmental effects, and unintentional application on non-target areas due to faulty spray control.

Human Error: Human error can be a major factor in the number and type of accidents that can occur during the aerial application of a pesticide. Three of the four aircraft accidents in 1983 and the spill in 1985 could be attributed to human error. The use of experienced and qualified pilots can help reduce the number of accidents caused by human error when treating a forested environment.

The types of accidents that can result from human error include: unintentional activation of the emergency release system, pilots' misjudgment causing loss of control while in flight or during takeoff and landing, and unintentional application to non-target areas.

Environmental Conditions: Certain environmental conditions can result in an accident. These conditions are the least controllable. These types of accidents include: loss of control and damage to the aircraft, and creating the need for the pilot to activate the emergency release system and dumping the pesticide load.

Accidents involving pesticides can also occur during the transport and mixing of pesticides on the ground; as was the case in 1983 when a truck transporting insecticide to a helicopter batch site lost control, left the road and crashed, spilling approximately 1900 gallons of formulated Sevin 4-Oil and diesel fuel into Willow Creek. Discussion of this accident is

factors set forth in FSM 3400 and be approved by the Chief of the Forest Service.

c. **Forest Service Manual Title 2100, Chapter 2150**. Pesticide Use, Management, and Coordination - This chapter contains policies and regulations for Forest Service direct or indirect (financial) involvement in pesticide use.

d. **Oregon and Washington State Forest Practices Acts**. Any project that may be implemented must comply with the laws, rules, and regulations of these acts. (Available at Oregon Department of Forestry offices or Washington Department of Natural Resources offices.)

e. **Federal Insecticide, Fungicide, and Rodenticide Act of 1972 as amended (Public Law 92-516)**.

f. **National Water Pollution Act amendments of 1972 (Public Law 92-500)**.

g. **Environmental Protection Agency Regulations**. These regulations include air and water quality standards that must be met.

h. **Endangered Species Act**. Threatened and endangered plant and animal species must be protected.

i. Any implemented project will comply with other applicable local, State, and federal laws, regulations, or policies.

j. Treatments will comply with the direction provided in the most recently approved Land Management Plan for National Forest System lands.

Final Environmental Impact Statements for the following Unit Plans apply to a portion of the area being considered in this analysis:

Grande Ronde Planning Unit, Hells Canyon National Recreation Area Environmental Impact Statement and Comprehensive Management Plan (Available at Forest Supervisor's Office, Wallowa Whitman National Forest, Baker, Oregon).

South Fork Planning Unit, John Day Planning Unit, and Silvies-Malheur Planning Unit, (Available at Forest Supervisor's Office, Malheur National Forest, John Day, Oregon).

Mt. Hood Planning Unit, Badger-Jordan Planning Unit, The Dalles Planning Unit, and East Hood River Planning Unit, (Available at Forest Supervisor's Office, Mt. Hood National Forest, Gresham, Oregon).

Elgin Planning Unit, (Available at Forest Supervisor's Office, Umatilla National Forest, Pendleton, Oregon).

Other land management plans applicable to lands considered in this analysis include:

Bear Springs Ranger District Multiple Use Plan and Barlow Ranger District Multiple Use Plan (Available at the Mt. Hood National Forest Supervisor's Office).

Warm Springs Indian Reservation Environmental Assessment Forest Management Plan (Available at Bureau of Indian Affairs, Department of Forestry, Warm Springs, Oregon).

2. Agency Goals.

Forest Service policy is to protect and preserve the forest resources of the Nation against destructive forest insects and diseases. Pest outbreaks will be prevented or suppressed by methods that will restore, maintain, or enhance the quality of the environment. These objectives are attained on non-Federal lands through cooperation with State Foresters or equivalent State officials. Pests are suppressed directly on National Forest System lands and in cooperation with responsible officials on other Federal lands.

A principal U.S. Department of Agriculture goal is to assure an adequate supply of high quality food and wood fiber and a quality environment for the American people. The USDA gives special emphasis to the development and use of efficient and environmentally acceptable integrated pest management systems.

Integrated Pest Management

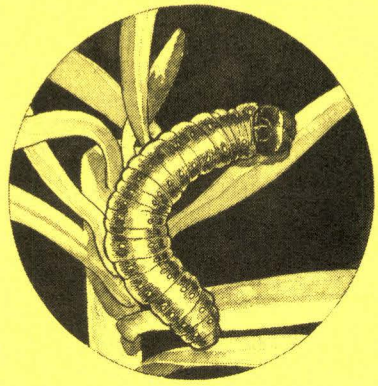
The USDA Forest Service Pest Management Policy is built on the concept of Integrated Pest Management (IPM). IPM is an ecologically based approach that includes the following types of activities: prevention, suppression, and post-suppression.

IPM prevention activities are part of land management at the most basic level. The ecological principles relating to pests are incorporated into forest and range management evaluations, planning and decision making. IPM includes an intensive continuing program of detection and evaluation of pest situations supplying information to planners and decision makers. The fundamental intent of prevention is to avoid creating ecological conditions that favor pests, to correct pest management-created conditions that foster further pest problems, or both.

Suppression, as related to IPM, involves evaluating the spectrum of possible suppression alternatives and, in each case, selecting an optimal strategy. That strategy may be a single tactic, concurrent measures, or a sequential combination of tactics. The evaluation considers the expected effectiveness of treatments in achieving resource management goals as well as such factors as economics, environmental concerns, and human safety. Suppression takes two forms: direct and indirect. Direct suppression means taking action directly against a pest to reduce its population; for example spraying insecticides, using prescribed fire, removing pests contained in infested materials, or releasing parasites or predators. On the other hand, indirect suppression is similar to prevention in that it involves altering conditions that favor a pest population, thereby causing a decline in numbers. Indirect suppression methods are applied to damaging pest populations that already exist, with the intent of limiting damage to tolerable levels.

Post-suppression activities include monitoring and post-treatment evaluations to determine the effectiveness and efficiency of suppression efforts. Effectiveness evaluations are ideally made in terms of net resource value changes rather than pest population numbers. To improve overall program performance, information gathered during the post-suppression phase is fed back into the system, and appropriate adjustments are made.

A feature of IPM is the consideration of other potential pest problems when making individual situation analyses. The goal is to avoid creating or intensifying one pest problem while attempting to alleviate another. The strength of the IPM philosophy is requiring that the three phases of pest management be incorporated into the broad arena of forest and range management. IPM is found in the planning, decision-making, and program implementation functions.



II. Alternatives

II. ALTERNATIVES

A. Introduction

The current western spruce budworm outbreak in the Pacific Northwest, which began in 1980, now includes an estimated 6 million acres. In 1987, a Region-wide western spruce budworm environmental analysis was conducted and an environmental assessment for western spruce budworm management prepared. In the Decision Notice and FONSI, five analysis units were selected for possible treatment with a biological insecticide in 1987. Contracts were awarded for treatment of approximately 250,000 acres in Oregon and Washington. The 1988 Environmental Assessment (EA) is an update of the 1986 and 1987 EA's and, as such, is not totally a new analysis; therefore, the alternatives considered in detail will remain the same. The alternatives presented in this environmental assessment are consistent with State and Federal resource management objectives and address the issues and concerns raised through scoping activities. These alternatives were developed and evaluated while several others were considered but eliminated from detailed study during the 1986 analysis process. Section C of this chapter lists a number of approaches which were eliminated from detailed study through scoping activities which defined the time and space dimensions appropriate to the analysis of the current western spruce budworm situation in Oregon and Washington.

B. Background Information

1. Size of the Area to be Analyzed

Scoping for the analysis of the current western spruce budworm outbreak in Oregon and Washington began in Pendleton, Oregon on September 10, 1984. At that time, officials representing several organizations with affected lands met to decide the first step in dealing with the situation. Those participating included: USDA Forest Service, USDI Bureau of Land Management and Bureau of Indian Affairs, Oregon Department of Forestry, and the Northwest Forest Pest Action Council (a subsidiary of the Western Forestry and Conservation Association). This group decided to file a Notice of Intent with the Federal Register to prepare an Environmental Impact Statement (EIS) for possible budworm control with chemical insecticides during the 1985 treatment season and conduct a preliminary economic analysis of the entire infestation area for later scoping by the same group. The economic analysis was based on a state-of-the-art western spruce budworm damage assessment model, a computer-assisted technology which has been evolving for the past few years. Based on the early 1984 economic analysis and additional detailed computer modeling in the summer of 1985, much of the infested area was eliminated from detailed study, and specific analysis units were identified for further consideration. Approximately 2.4 million acres were considered in detail in the 1986 analysis. In the assessment, 18 analysis units, totaling 900,000 acres, had a benefit/cost ratio greater than one.

Section II B1, Pages 23 through 25, (Background Information, Size of the Area to be Analyzed) of the Environmental Assessment document Western Spruce Budworm Management in Oregon and Washington During 1986, discusses the history and background of the meetings and decisions during 1984 and 1985 in greater detail.

During the summer of 1987, spruce budworm feeding and reproductive activity continued at high levels. In the Blue Mountains of northeastern Oregon, defoliation of new growth in many stands approached 100 percent, with "hotspots" suffering relatively high percentages of total tree foliage loss, top kill and, in some cases, tree mortality. Similar intensities of defoliation were noted in other parts of Oregon and Washington as well. The 1987 annual aerial survey, conducted in August, showed that the total area of detectable defoliation had decreased to about 5.8 million acres. However, some of the infested acreage occurred in areas where visible budworm defoliation had not been detected previously during this outbreak. For the 1988 analysis, it was decided that only those units with a benefit/cost ratio of more than .78 (at the 4 percent discount rate, 1 percent real stumpage price increase, and $11.45 treatment cost) in the 1986 document would be reanalyzed. In addition, some boundaries of existing analysis units were adjusted and some new units were added. A total of 21 analysis units, involving almost 2.5 million acres, were considered in detail.

2. Timing of the Analysis and Decision Implementation

Early in January 1985, during scoping meetings, it was recognized that producing an EIS having alternatives that proposed the aerial application of chemical insecticides would require considerable effort. In addition, the continued improvement of formulations and application of the biological insecticide, Bacillus thuringiensis (B.t) indicated that possibly B.t. could be used on an operational basis against western spruce budworm in Oregon. As a result, an environmental assessment was prepared (USDA Forest Service 1985) and a B.t. project evaluating several formulations of B.t. was conducted in 1985 on the Malheur National Forest. All treatments either achieved or were very close to achieving the objectives of the project. Consequently, USDA Forest Service entomologists now recommend B.t. for use in operational budworm suppression projects.

A discussion of this process, and the 1985 B.t. project, are discussed in more detail in the Environmental Assessment document for Western Spruce Budworm Management in Oregon and Washington During 1986 in Section II B2, Pages 25 and 26, Timing of the Analysis and Decision Implementation; and Section II B3, Page 26, B.t. Operational Evaluation Results.

In 1985 and early 1986, an environmental analysis for 1986 was conducted and the Environmental Assessment document prepared (USDA Forest Service, 1986). The alternative of direct suppression with a biological insecticide was selected for six of the analysis units. No suppression projects were conducted due to lack of funds. The outbreak continued through the summer of 1986. In the fall of 1986, the decision

was made to conduct an analysis for 1987 and an Environmental Assessment document prepared (USDA Forest Service, 1987). Based on this analysis, a decision was made to treat 500,000 acres with a biological insecticide. However, because of funding limitations, only 250,000 acres were contracted for. Actual treatment was carried out on about 135,000 acres in both Oregon and Washington.

3. Time Scope of the Analysis

Based on records of past infestations, USDA Forest Service entomologists estimate the current western spruce budworm outbreak in Oregon and Washington will persist somewhere within the vegetative host type for another 6 years (10 years for the total outbreak). It was suggested, therefore, that an environmental analysis should be conducted for a 10-year program of budworm management and an EIS written that would allow tiered environmental assessments (EA's) to be produced each subsequent year. Discussion of this proposal during scoping, however, revealed several facts. In recent years, considerable controversy has surrounded decisions to aerially apply chemical pesticides on publicly-owned forest land in the Northwest. Related issues have been debated in administrative appeals and in the courts. This controversy has necessitated the preparation of environmental impact statements for each project proposal involving the aerial application of chemical insecticides such as carbaryl for which a worst case analysis of risks to human health is needed.

Accounting for the effects of entire budworm outbreaks and their sporadic occurrence could have implications for long-term management strategies on several National Forests in Oregon and Washington. These implications, such as possible changes in allowable timber harvest levels, are most appropriately addressed in the Land and Resource Management Plans now being prepared for each National Forest in the Northwest. Since the technology of projecting budworm impacts has only recently become available, it was not utilized for the present round of planning. The effects of budworm outbreaks are expected to be addressed during the next 10-year National Forest planning cycle.

Several alternative strategies for responding to the expected 10-year western spruce budworm outbreak could be analyzed. Based upon the results of other program analyses, such as the recent National Gypsy Moth EIS, a likely outcome would be a decision to adopt a plan of "integrated pest management" (IPM). Since IPM is already a matter of Forest Service policy, there seems little reason to pursue an expensive analysis and documentation procedure to reconfirm existing policy.

For the reasons explained in the preceding paragraphs, the alternative of preparing an EIS for a 10-year budworm management program was eliminated from detailed study.

4. Insect Pests to be Analyzed

Several forest insect pests similar to the western spruce budworm (the Modoc budworm, (C. retiniana), the black-headed budworm, (Acleris gloverana), and budmoths of the genus Zeiraphera), have populations in an outbreak status in various locations in the Northwest. Populations of the Modoc budworm in southern Oregon now appear to be declining. Black-headed budworm and budmoth infestations have not yet become widespread enough to raise a high level of management concern. During scoping, entomologists expressed their opinion that the damaging western spruce budworm populations comprise the significant issue needing analysis. Alternatives that would address Modoc budworm, black-headed budworm, or budmoth populations were eliminated from detailed study.

5. Division of the Area for Analysis

The areas scoped for detailed study could have been divided for analysis in several ways. The purpose of dividing the area is to provide site-specific information for the Responsible Official to consider when deciding among the alternatives. Analysis of the entire 6 million acres as one unit is obviously inappropriate because of the highly variable resource conditions encountered in various locations of the infestation. In past budworm outbreak analyses, attempts were made to divide the total area into areas called entomological units (EUs).

The objective of establishing an EU is to create an area for insect control purposes that can stand on its own, i.e., an area that, once it has been treated, would see minimal reinfestation from surrounding areas. Criteria used to delineate EUs are: **a.** areas where aerially and ground-detectable defoliation is confined to isolated areas distinctly separated from other defoliated forest land, and **b.** where affected areas are separated by physical features such as prominent ridges or significant breaks in the vegetative host type. Selecting these physical features requires professional entomological judgment since the object is to choose features that will minimize the chances of adult moths invading a treated area from an adjacent untreated area. A primary purpose of using the EU as an analysis breakdown is to minimize the number of times treatment is needed to keep budworm populations at non-damaging levels within a given outbreak period. In theory, if each acre within a selected EU were effectively treated, retreatment within the same outbreak period would not be needed.

Obtaining complete treatment coverage of an EU in large continuous areas of infestation with poorly defined natural breaks (such as eastern Oregon) becomes difficult. During the 1982 and 1983 treatment projects in eastern Oregon, a number of untreated areas were left distributed throughout treated areas due to such factors as an overall shortage of State and Federal funding, non-participating private landowners, stream buffers, and land management objectives. Thus, the entomological unit concept was compromised. In most of the treated areas, budworm populations have been reestablished. It appears that, in these areas, the entomological unit concept of structuring

treatment areas is inappropriate. A more effective approach is to divide the area into analysis units which are small enough to meet the decision making needs of land managers. Analysis units (AU's) may be delineated according to the criteria defined above for EUs, as well as such criteria as ownership boundaries, management objectives, or municipal watersheds. This usually results in having units smaller than an EU, where land management is more intensive, where greater per acre resource values are located, or both. As a consequence of such an approach, however, reinfestation is assumed, and some areas may need more than one treatment during an outbreak cycle.

Within analysis units, there often are small areas of higher values, such as plantations, seed orchards, and cut areas planned for natural regeneration. While these smaller areas may have high per acre values at risk, their values become insignificant when averaged out over the acreage of the larger analysis unit. A number of the analysis units contain these relatively small special areas, but the current computer model being used in the analysis does not account for the special types of budworm losses on these specific areas. Analyzing these smaller areas for a decision will need to be done by the local field units.

C. Alternatives Considered but Eliminated from Detailed Study

Alternatives that were considered but eliminated from detailed study were:

1. Direct Suppression using Chemical Insecticides

2. Suppression using Silvicultural Management Techniques

3. Suppression using Biological Methods other than B.t.

These alternatives are discussed in detail in the Western Spruce Budworm in Oregon and Washington During 1986 Environmental Assessment Document, Section IIC, Alternatives Considered but Eliminated from Detailed Study, Pages 29 through 32. The above three alternatives were eliminated for the same reasons as discussed in the 1986 and 1987 EA's.

D. Alternatives Considered and Studied in Detail

1. Alternative 1 - No Action

With this alternative, no direct suppression action would be taken to reduce the western spruce budworm populations to nondamaging levels during 1987. The budworm infestation would be allowed to continue until it collapses due to natural factors or until a subsequent environmental analysis finds that control measures would be needed.

Current management practices such as timber harvesting and road building in the infested areas would continue. Scheduling and timing of these activities may be affected by the budworm outbreak.

Western spruce budworm activity would be monitored annually with an aerial sketchmap survey to determine the extent of visible defoliation.

2. Alternative 2 - Direct Suppression with Biological Insecticide (B.t)

a. Introduction

This alternative would involve the aerial application of biological insecticide to selected analysis units with the objective of reducing budworm populations to nondamaging levels for at least a major portion of the current outbreak. Depending upon post-treatment rates of population build-up due to resurgence, reinvasion, and unit configuration, retreatment of some areas may be indicated during the next 10 years in order to maintain the objective.

Only formulations of B.t. registered by the EPA for use against the western spruce budworm by aerial application would be employed.

Streams would not be buffered.

b. Mitigating Measures

1. Protection of Water-Related Resources

Aerial insecticide application near streams and open water is controlled by State law. In Oregon, State regulatory agencies have agreed that B.t. may be aerially applied parallel to and up to the edges of streams and open water. A variance must be obtained from the Washington State Department of Ecology to apply B.t up to the edges of streams in that State.

The following measures will be used to minimize the probability of unintentional adverse effects on water-related resources and non-target organisms from spills or application errors:

Aircraft spray equipment calibration testing over wetlands or floodplains will be prohibited.

Transportation of insecticides or fuel on roads within municipal watersheds will not be permitted.

Helispots will not be located in or adjacent to meadowland or floodplains.

Wetlands, including lakes and ponds, which are large enough to identify from the air will not be oversprayed with insecticides. There may be relatively small wet areas that, because of the tree canopy cover, cannot be identified from the air which will be unavoidably but inadvertently sprayed.

2. Protection of Non-target Organisms

The Project Director of any spraying operation will coordinate with local State and Federal land managers to ensure that appropriate protection measures are implemented to mitigate possible adverse effects to the nesting habitat of eagles and other raptors. Mitigating measures for threatened or endangered species developed with the concurrence of the U.S. Fish and Wildlife Service, will be incorporated into the project operations plan to ensure that treatment and related activities will have no effect.

In areas planned for treatment, the Project Director will coordinate with the Forest Service Area Ecologist to determine what action is appropriate to assure that threatened or endangered plants are protected. Areas important to threatened or endangered species will be avoided if necessary.

3. Cultural Resources

Possible cultural resource sites in previously unsurveyed and undisturbed areas are a concern. The Project Director of treatment projects will ensure that areas such as planned helispots, truck parks, or staging areas are surveyed for cultural resource values by a qualified person before ground-disturbing activities occur. Any cultural resource sites discovered will receive appropriate protection.

4. Monitoring

The Project Director will prepare and implement a written monitoring plan, ensuring that experienced people and recognized authorities are consulted during plan preparation. The four following purposes of monitoring will be considered in the plan and implemented if necessary.

a. To measure the accomplishment of the project insect population reduction objectives.

b. In areas planned for B.t. application, to measure the effects of insect food supply reductions on insectivorous birds. Since B.t. is specific to lepidopterous insects, no monitoring needs for effects on fish are anticipated.

c. To measure insecticide residue in domestic water supplies within applicable analysis units.

d. To provide timely feedback to the Project Director about the conduct of the operation. If something is going wrong, the Project Director will be notified immediately.

5. Pre-treatment Reviews

Budworm population levels must be verified through early spring larval sampling before commencement of insecticide application. In 1988 this takes on special significance because of the long, warm and dry autumn in 1987. This weather situation may be responsible for the collapse of populations.

Before treatment, the Project Director will review the current status of Analysis Units that fall within wilderness, roadless, or further study areas to ensure that any treatment decisions that may have been made on these areas remain valid.

6. Spray Operations and Contract Administration

Experience during recent years has shown that certain items concerning the structure and administration of spray contract operations must be emphasized in order to ensure safe and satisfactory work. These items are highlighted in the following paragraphs:

Insecticide formulations will be applied under weather conditions that comply with the manufacturer's recommendations. These standards vary somewhat, depending upon the particular formulation being used. Such factors as air movement, wind speed, air temperature, relative humidity, probability of rain, presence of moisture on foliage, air turbulence, temperature inversion, and visibility will be considered when making decisions to spray or not to spray. Tolerance guidelines for each of these environmental parameters are included in the insecticide application contract.

In order to minimize the range of spray droplet size, the use of rotary atomizer nozzles will be required.

Contractors' equipment will be required to meet all applicable operational and safety regulations. Inspections will be conducted before and during operations. Tank trucks are particular items of interest.

Pilot cars will be used to guide the contractor's insecticide transportation vehicles to the helispots.

The Project Director will ensure that all contract administration personnel are fully qualified to perform their functions and are fully aware of their responsibilities and authorities.

Application Team Leaders and other contract administration personnel will exercise shut-down authority when they observe aircraft safety violations.

The Project Unit Director will place special emphasis upon minimizing the following types of errors:

Spraying areas that have been designated for protection.

Treating designated areas more than once.

Spraying areas outside the designated spray blocks.

Non-uniform coverage of the target area.

In order to control and monitor insecticide application, each application aircraft, or team of aircraft, will be accompanied by an observation aircraft staffed with a fully qualified aerial observer. Each observer will be familiar with the local terrain and have authority to control all activities of the application aircraft. Observers and application pilots will fly each spray block for familiarization prior to spraying.

A written project plan will be developed for the implementation of spray operations. In addition to routine considerations, the project plan will specifically address safety, public notification, monitoring, and accidents and spills.

For any project that is implemented, the Project Director will prepare and follow a public information plan to ensure that timely notification is given about when and where spray operations will take place. Two general groups need notification, the general public and organizations that may have people working or recreating in the area. Members of the public will be given the opportunity to receive individual notice if they make a special request. In particular, range permittees have requested notification. The public will be notified about any possible adverse effects that spray may have on automobile finishes. Warning signs which are posted on the perimeter of treatment units will be bilingual (English and Spanish).

The Project Director will prepare and follow a written contingency plan for dealing with accidents and insecticide spills. The plan will specify other agencies' involvement, listing authorities and responsibilities. The plan will detail the notification procedures. The provisions for minimizing the potential adverse effects from spilled B.t. will be specified. B.t. formulations used in the project will be analyzed for the presence of any clinical significant pathogens.

E. Comparison of Alternatives

At the beginning of the environmental analysis process, the interdisciplinary (ID) study team set out to specify the issues, concerns, and opportunities associated with the current western spruce budworm outbreak (and possible treatments) in Oregon and Washington. By updating items documented in previous analyses through a public involvement process, the ID team identified the following major issues and concerns:

1. Potential effects on wood fiber production.

2. Potential effects on water quantity and quality.

3. Potential effects on terrestrial wildlife and domestic livestock.

4. Potential effects on aquatic invertebrates and fish.

5. Economic efficiency and local economic impacts.

6. Potential for human health hazards.

7. Uncertainties of achieving lasting budworm population reductions.

To respond to the budworm situation, the alternatives (with mitigation measures) previously described in this section of the EA were developed. Either of the alternatives, if implemented, would have environmental consequences related to each of the seven major issues and concerns. In addition, the alternatives would have environmental consequences related to several issues and concerns identified as being minor. These consequences (or effects) are discussed in detail in Chapter IV of this EA.

The environmental consequences of the alternatives in relation to the identified issues and concerns are summarized in Table 3.

Table 3. Comparison of alternatives

MAJOR ISSUE	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 TREATMENT WITH B.t
1. Potential Effects on Wood Fiber Production	Maximum amount of growth loss, top-kill, reduced seed production and tree mortality. Natural regeneration of host species reduced during outbreak	Less growth loss, top-kill, mortality, and more seed production than Alternative 1. Over rotation (70 yrs.) could increase wood fiber production an average of 1067 BF per acre in treated areas with B/C's greater than 1.0. Chances of establishing stands thru natural regeneration increased.

Table 3. Comparison of alternatives (cont.)

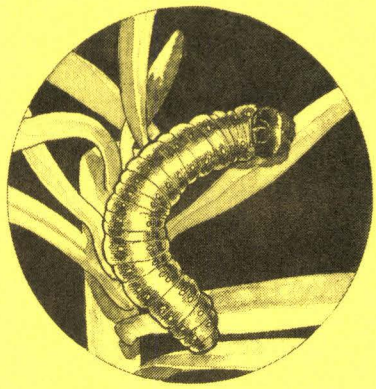
MAJOR ISSUE	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 TREATMENT WITH B.t
2. Potential Effects on Water Quantity and Quality	Very little effect on water quantity and quality.	No effects on quantity. No important effects on quality from normal spraying operations. Spills involve short-duration contamination.
3. Potential Effects on Terrestrial Wildlife and Livestock	Minor reduction in hiding and thermal cover for big game. Slight benefit to cavity nesters. Slight increase in forage production for domestic livestock and big game. Slight overall benefit to wildlife and domestic livestock.	Slight, short-term disturbance of wildlife populations by aircraft. Slight adverse impact on some non-target moth and butterfly species. No effects on other wildlife species present.
4. Potential Effects on Invertebrates and Fish	No known effects on aquatic invertebrates. Slight overall benefits to fisheries.	No threat to aquatic organisms from normal project operations. Adverse effects of spills are short term and limited to short stream reaches.
5. Economic Efficiency and Local Economic Impacts	Long-term timber supply for local processing and support industries less than that of Alternative 2. Areas with substantial mortality may have short-term benefit to local economy due to salvage No treatment costs; thus, cost-benefit analysis not appropriate for this alternative.	Greater long-term timber supply sets stage for higher levels of future local and regional economic activity. Short-term bolstering of local and regional economies due to investment in treatment project Depending upon scenario, 922,000 to 1,519,000 acres have B/C ratios greater than 1.

Table 3. Comparison of alternatives (cont.)

MAJOR ISSUE	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 TREATMENT WITH B.t
6. Potential for Human Health Hazards	Unchanged from those of normal forest management operations.	Slight increase from that of Alternative 1.
7. Uncertainties in Achieving Lasting Budworm Population Reductions	Outbreak runs normal course of rise, peak, and decline.	Outbreak not allowed to run normal course Greater risk of re-invasion as size of treatment unit decreases. Slight risk of resurgence in treated areas.
OTHER COMPARISON FACTORS		
8. Potential Effects on Visual Resources	Discoloration of trees until outbreak collapses. Areas with high tree mortality levels visible for several years after outbreak collapses.	Trees exhibit green appearance from 1989 on if intermediate treatments are done as needed.
9. Time Constraint	No time constraints	EA must be completed and contracts let by mid April to allow treatment to be done at appropriate time.

Table 3. Comparison of Alternatives (cont.)

OTHER COMPARISON FACTORS	ALTERNATIVE 1 NO ACTION	ALTERNATIVE 2 TREATMENT WITH *B.t*
10. Local Airport Use	No increased local airport use.	Potentially, local airports could be used 1 to 3 hours per day for 10 to 25 days. Numbers of aircraft would increase with numbers of acres treated.
11. Project Personnel Needs	No additional personnel needed.	45 to 50 people needed for 2 months for each 100,000 acres treated.
12. Treatment Cost	No treatment cost.	Costs estimated to range from $16.50 to $21.50 per acre.
13. Value of Contracted Services	No additional contracted services.	Value of contracted services estimated to range from $6.45 to $10.10 per acre treated.
14. Potential Effects on Wilderness Values	No adverse effects since budworm outbreak is a naturally occurring event.	Application would interfere some with natural processes.
15. Threatened and Endangered Species	No known effects on threatened or endangered species.	No effects on threatened or endangered species with compliance to appropriate mitigating measures.
16. Sharing of Treatment Costs	No direct suppression treatment costs will be incurred.	Federal and/or State funds may be available to private landowners; level unknown but probably lower than those of past projects



III. Affected Environment

III. AFFECTED ENVIRONMENT

A. Host Vegetation

In eastern Washington, 3,255,000 acres of Douglas-fir and associated species on forest land are considered hosts for western spruce budworm. An estimated 3,138,000 acres of host Douglas-fir and associated species are located in eastern Oregon. These acreages include Douglas-fir, white fir, and grand fir types (Ron Gedney, Pacific Northwest Forest and Range Experiment Station, personal communication, 1985). A significant percentage of ponderosa pine types, which contain fir components, are also affected by western spruce budworm outbreaks. An acreage estimate of these susceptible ponderosa pine types is not available.

In eastern Oregon, a number of factors, including past timber harvest practices, fire exclusion, and management philosophy, have resulted over several decades in changes in the structure and composition of forests, resulting in an increase of fir, particularly true fir (Hall 1981, West 1969). Eastern Washington forests have experienced similar management histories with comparable results. Where multiple-canopy stands have been created by harvest practices or by fire exclusion, the risk and likelihood of defoliation by insects is increased. Risk of defoliation is also increased on warmer, drier Douglas-fir plant associations (Fellin 1983). Stands containing higher percentages of non-host (resistant) species such as ponderosa pine or western larch experience less damage from defoliation and reduced growth loss (Fellin 1983). White fir and grand fir forest types, and to a lesser extent Douglas-fir types, are recognized as having some potentially serious insect and disease problems, among which are Douglas-fir tussock moth, western spruce budworm, root rots, and stem decay. However, on many sites in eastern Oregon (white fir/twinflower/forb and white fir/huckleberry sites), the true firs are not only the best adapted but also will out-produce other species by at least 20 percent in terms of volume production (Hall 1980 and 1981). As a result, while recognizing the increased hazard, forest management philosophy has often favored grand fir/white fir.

B. Classified Streams, Watersheds, Floodplains, and Wetlands

Numerous streams occur in each of the units being analyzed for treatment of spruce budworm. The approximate miles of classified streams in each analysis unit are shown in Table 4, followed in Table 5 by a comparison of stream classifications used by the USDA Forest Service and the States of Oregon and Washington.

Table 4. Approximate Miles of Classified Streams in each Analysis Unit (USDA Forest Service classification system).

Analysis Unit	Miles by Forest Service Stream Class				
	Class I	Class II	Class III	Class IV	Total Miles
Barlow	91	61	87	492	731
Bridge	9	18	21	21	69
Dalles	81	19	16	196	312
Hehe	45	17	6	34	101
High Rock	95	64	91	514	764
Huckleberry	12	26	92	189	319
Jefferson	45	68	18	66	197
Jubilee	20	36	64	100	220
Meacham	4	8	10	34	56
Mill	6	4	27	14	51
Mt. Hood	137	93	132	744	1106
Reynolds	6	14	46	33	99
Ruckel	8	40	40	72	160
Shitike	13	29	23	33	98
Simcoe	33	10	67	179	289
South NRA	52	23	43	132	250
Starkey	2	16	14	40	72
Target	5	30	35	48	118
Watershed	7	19	18	19	63
White River	169	114	163	916	1362
Wilson	15	29	23	33	98

Table 5. Comparison of USDA Forest Service Stream Classifications with those used by the states of Washington and Oregon.

USDA Forest Service Stream Classification

		Class I	Class II	Class III	Class IV
State of Oregon Stream Classification	Class I	X	X		
	Class II			X	X
State of Washington Stream Classification	Type 1	Does not correspond to USFS Classes			
	Type 2	X			
	Type 3		X		
	Type 4			X	
	Type 5				X

The analysis includes Class IV streams which, by definition, are intermittent and, therefore, difficult to identify. In most instances, it is assumed the number of miles of Class IV streams in each unit equals one-half the sum of the mileages of all other classes. This recognizes that during the period when spraying is likely to occur, a significant number of headwater streams, generally Class IV's, are flowing water (snowmelt runoff).

These streams provide habitat to a variety of aquatic life forms. More information about these species can be found in the following section titled Non-Target Organisms.

Two municipal watersheds are located within the Barlow Analysis Unit located primarily on the Mt. Hood National Forest. These watersheds provide water supplies to the residents of the City of The Dalles and the community of Dufur, Oregon.

On the Warm Springs Indian Reservation, a few families draw their domestic water directly from the Deschutes River. Runoff from the Jefferson, Wilson, Shitike, and Hehe Analysis Units potentially affects water quality in the Deschutes River, although these areas represent a relatively small part of the total watershed.

The City of Goldendale, Washington gets its water from about 60 springs located in the Simcoe Analysis Unit in Sections 15, 16, 21, 22 of T. 6 N., R. 15 E.

Other analysis units characterized by high levels of water use for domestic supplies or recreational use include: The Dalles, White River, Barlow, Jefferson, Wilson, Shitike, and Hehe Analysis Units. While all analysis units supply water for similar uses, the level of use is much greater in these units which are located nearer to major population centers.

Livestock water developments are common on nearly all National Forest and BLM lands located within analysis units.

Wetlands, other than those associated with the streams and lakes already mentioned, consist of small wet meadows or marshes associated with springs, seeps, or other small lakes. Identification of the larger of these wetlands will allow project personnel to designate them as springs and seeps which are too small to be identified from the air. These small wetlands may inadvertently be treated.

Table 6: (Continued)

Obscure buttercup	Ranunculus reconditus
Columbia cress	Rorippa columbiae
	Silene scaposa var. scaposa
	Silene spaldingii
	Thelypodium eucosmum
	Thelypodium howellii var. spectabilis

Table 7: Species of interest or special concern listed by the States of Washington and Oregon that may occur within the Western Spruce Budworm Analysis Units.

Lewis' woodpecker
Spotted Owl
Golden eagle
Osprey
Prairie falcon
White-headed woodpecker
Turkey vulture
Goshawk
Fisher
Yellow tailed cuckoo
Black-beaked three-toed Woodpecker

Western gray squirrel
Kangaroo rat

Malheur sculpin
Southern alligator lizard
Ring-neck snake

Egleis' fritillary
Sylvan hairstreak butterfly
High mountain blue butterfly
American butterfly
Cooley's tingid

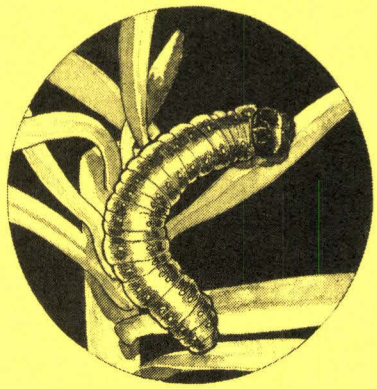
Complete listings of wildlife species occurring within the analysis units can be found by referring to the appropriate local land-use plan. These land-use plans and their availability for review are shown in Section I.C.1. of this EA. These listings do not include invertebrate species. No extensive listings of invertebrates have been completed.

Domestic livestock, mainly cattle, but some sheep, are found in nearly all analysis units. Many of these animals graze National Forest land under permit, with most use occurring during the summer months. Significant numbers of livestock also graze on private lands adjacent to the National Forests. Many of these private holdings are also included in the analysis units being considered for treatment.

2. Aquatic Invertebrates and Fish

An estimated 110 miles of chinook salmon (Onchorhynchus tshawytscha) streams, 550 miles of steelhead trout (Salmo gairdneri) streams, and 1450 miles of native trout streams are located within the analysis units. Chinook salmon and steelhead trout streams are regarded as highly sensitive because of the high economic and intrinsic values of anadromous fish. Considerable State and Federal funding is currently being expended to improve anadromous fisheries within the Columbia River system. Efforts are aimed at increasing existing populations and restoring populations to streams that once supported natural runs. The present net value of the anadromous fishery resources within all analysis units is estimated to be over 6 million dollars.

Fish species of particular interest are listed in Tables 6 and 7. Other fish considered to have economic importance occur in some of the analysis units. These include whitefish (Prosopium williamsoni), smallmouth bass (Micropterus dolomieu), and brown bullhead (Ictalurus nebulosa). Complete listings of fish occurring in the area can be found by referring to the previously mentioned land use plans.



IV. Environmental Consequences

IV. ENVIRONMENTAL CONSEQUENCES

A. Introduction

This section describes the environmental effects projected as a result of implementing either of the proposed alternatives.

At the beginning of the environmental analysis process, the interdisciplinary (ID) team set out through a scoping process (see Chapter V) to specify the issues, concerns, and opportunities associated with the current western spruce budworm outbreak (and possible treatments) in Oregon and Washington. By updating items documented in previous analyses through a public involvement process, as well as considering current input, the ID team found that the seven major issues and concerns described in the 1986 and 1987 analyses were still valid and that no new issues and concerns had surfaced. These are:

1. Potential effects on wood fiber production.

2. Potential effects on water quality and quantity.

3. Potential effects on terrestrial wildlife and domestic livestock.

4. Potential effects on aquatic invertebrates and fish.

5. Economic efficiency and local economic impacts.

6. Potential human health hazards.

7. Uncertainties of achieving lasting budworm population reductions.

To respond to the budworm situation, the alternatives (with mitigation measures) previously described in Section II of the EA were developed. Each of the alternatives, if implemented, would have environmental consequences related to each of the seven major issues and concerns. In addition, these alternatives would have consequences related to several other issues and concerns which are considered minor based upon the information gathered through the scoping process.

These consequences (or effects) comprise the information needed by the Responsible Official to select an alternative for implementation.

B Consequences of Alternatives

1. Potential Effects on Wood Fiber Production

a. Introduction

This section describes how spruce budworm defoliation beneficially or adversely affects tree growth and, consequently, wood fiber production. The effects of the alternatives are also described in general terms as they relate to wood fiber production. A more detailed description is not possible here because the effects are extremely variable, depending on each stand's species composition, climatic factors, topography, and management objectives.

A substantial amount of information is available about budworm-caused impacts on individual trees and is summarized in the following paragraphs. While some research is currently being conducted, less information is available about budworm-caused stand impacts. This is especially true for long-term stand development which is particularly important for an economic evaluation. This necessitates making assumptions about these impacts and their implications in order to place a value on timber resource losses.

Timber stands affected by the current spruce budworm outbreak will suffer various types and degrees of damage to wood fiber production, the most significant of which is growth loss. Other types of damage include tree mortality, top-kill, deformity, and reduced seed production, all of which may occur as high magnitude effects on relatively small areas. These small areas are usually irregularly distributed through the general zone of infestation and cause considerable concern for local land managers.

The damage to wood fiber production was estimated using a state-of-the-art western spruce budworm damage assessment model, a computer-assisted technology which has been evolving for the past few years (Appendix E).

b. Growth Loss

1. Alternative 1 - No Action

A major impact of budworm defoliation on a timber stand is growth loss. By feeding on tree foliage, budworm larvae reduce the host tree's vigor, resulting in reduced height and diameter growth rates. The net effect on the growth rate of a stand of trees depends on several factors, including species composition, tree size, tree age, stocking levels, and site quality. Stands with a large proportion of host tree species are more prone to sustaining growth loss than stands composed of a mixture of species. Grand fir has been shown to suffer more damage than Douglas-fir (Carolin 1975). Numerous studies have shown that radial growth reduction lags behind foliage removal by 1 to 3 years (Alfaro et al. 1982, Crimp 1982). Similarly, growth recovery lags behind cessation of defoliation.

Radial growth loss is most often expressed relative to pre-outbreak growth rates. Shepherd et al. (1977) observed an annual increment reduction of 40 to 80 percent in Douglas-fir. Gregg et al. (1979) found the reduction in mean annual increment relative to predicted growth averaged 12 percent in Douglas-fir and 27 percent in true fir after 5 years of repeated defoliation.

Height growth is also affected by budworm defoliation. Severely defoliated Douglas-fir in British Columbia produced no height growth for a period of 10 years (Shepherd et al. 1977). In Washington, where lighter defoliation occurred for a shorter time period, height growth loss was

compensated by a lateral shoot quickly achieving dominance. The proportional loss of height growth was similar to or less than diameter growth (Scott and Nichols 1983).

The combined loss of radial and height increment results in stand volume loss over time. Stand volume losses are usually calculated as the difference between observed volume and a predicted volume. Harvey (undated) reports average stand volume in north-central Washington after a 10-year outbreak as a 2.9 percent loss of predicted growth. In Idaho, stand volume losses were calculated as 1 percent less than predicted growth (Bousfield et al. 1975).

In young stands with apparent top-kill or mortality, precommercial thinning may be postponed until the outbreak subsides to assure that severely damaged trees are removed and the best trees are retained for future growth. Rescheduling this thinning defers the benefits of "release" in the stand and probably will lengthen the rotation age.

Stand volume losses can be compensated for by increases in radial growth of nonhost species such as pine growing within the defoliated stand. Carlson and McCaughey (1982) have shown an apparent radial growth acceleration of pine growing in defoliated stands of western Montana. This effect has also been demonstrated in Douglas-fir tussock moth infestations by Brubaker (1978) and Wickman (1978).

Under the No Action Alternative, the maximum amount of budworm-caused growth loss would continue until the population collapses due to natural regulating factors or until a subsequent analysis determines that suppression measures are needed.

2. Alternative 2 - Direct Suppression with B.t.

It is projected that implementation of this alternative in an analysis unit would result in a level of budworm population control that would avert most of the future predicted loss of wood fiber production due to the current outbreak. If all of the analysis units considered in the Environmental Assessment were treated with B.t., it was estimated that, over the rotation period, the increase in wood fiber production over the No Action Alternative would be 1.5 billion board feet (BF), an average of 553 BF per acre. Over the rotation period this equates to about 8 BF per acre per year.

The magnitude of wood fiber production effects is determined by the degree that treatments reduce spruce budworm populations. Many uncertainties and unknowns associated with the rise and fall of budworm populations and their interactions with forest ecosystems exist. B.t. has demonstrated varied effectiveness in some past projects. Contemporary projects, however, use improved formulations of insecticide, different application parameters, and revised timing of application. The 1985 B.t. operational evaluation in eastern Oregon showed very acceptable results.

Due to the analysis unit concept, budworm population levels in the next several years following treatment are uncertain. Sources of reinvasion may be present within, or adjacent to, any analysis unit. If these sources cause populations in a treated area to increase, a second insecticide application may be needed during the current outbreak to avert the predicted timber losses. Similarly, if populations rise due to resurgence from endemic or residual populations, a second treatment would also be needed.

c. Mortality

1. Alternative 1 - No Action

Harvest volume impacts due to tree mortality will depend on both the intensity and duration of the infestation. In addition, stocking levels, degree of mortality concentration, the distribution of mortality among diameters, nonhost growth interactions, physiological stem damage, stand vigor, and other conditions will substantially influence resultant final harvest volumes. In some mature stands, trees defoliated by the western spruce budworm may also be attacked by other insects such as the Douglas-fir beetle or the fir engraver beetle (Fellin and Dewey 1982). These pests prolong the occurrence of mortality beyond the period of budworm infestation. Scattered mortality may be beneficial in some instances. For example, local woodcutters gain short-term benefits if they are allowed to salvage dead trees. In some stands, mortality of budworm host trees may actually accelerate the growth of nonhost trees.

In an extreme case, tree mortality amounted to 39 percent of the total number of trees per hectare, though it was unevenly distributed among crown classes with smaller, suppressed trees sustaining higher mortality (Alfaro et al. 1982). Harvey (undated) indicated that, in Washington, four percent of the trees infested by budworm had died. Therefore, mortality was not considered a significant effect of budworm defoliation when looking at the infestation area as a whole.

Impact information collected in several moderately damaged stands in 1986 on the Malheur National Forest (unpublished data on file at Forest Pest Management, Regional Office, USDA Forest Service, Portland, Oregon) showed Douglas-fir mortality to range from 0 to 18 percent, and grand fir mortality from 0 to 5 percent. Heavily damaged stands that were sampled had little or no grand fir, with Douglas-fir mortality ranging from 6 to 23 percent. With the additional budworm that has occurred in 1986 and that is expected in 1987, the amount of mortality is expected to increase.

Under this Alternative, the forests would exhibit maximum amount of mortality caused by an outbreak allowed to continue until collapse due to natural regulating factors.

2. Alternative 2 - Direct Suppression with B.t.

Under this Alternative, there would be very little budworm-caused mortality in stands which have not already experienced tree mortality. In stands which have already experienced tree mortality, some of the additional mortality expected would be averted, the amount being dependent upon site and stand conditions.

d. Top-Kill and Deformity

1. Alternative 1 - No Action

Top-kill, resulting from defoliation in timber stands, has three important consequences. First, height growth is reduced during the infestation. Second, when growth resumes, deformation is likely. Third, in large trees, stem decay may occur. In general, assessments of top-kill have shown its frequency to vary among and within stands. Evidence of old top-kill was found in 11 percent of the standing Douglas-fir surveyed in British Columbia, but ranged from 0 to 70 percent within individual stands (Collis and Van Sickle 1978, Shepherd et al. 1977). In Idaho, 20 and 70 percent of the grand fir in two stands had evidence of top-kill from previous budworm outbreaks (Ferrell and Scharpf 1982). In eastern Oregon, Sandquist and Gregg (1985) evaluated bare top (i.e., portion of top devoid of foliage after the current year's defoliation has taken place) as a percentage of tree height on four 10-point cluster plots. Bare tops were expressed in percent of total tree height. Percent of grand fir and average percent of bare tops ranged from 7.7 percent with an average of 1.8 + 7.2 percent bare top, to 94.2 percent with an average of 13.6 percent + 6.4 percent bare top.

Impact information was collected in stands on the Malheur National Forest in Spring 1986 (unpublished data on file with Forest Pest Management, Regional Office, USDA Forest Service, Portland, Oregon) in stands showing moderate to heavy damage after four or five years of visible defoliation. In stands with moderate damage, the percentages of Douglas-firs top-killed for small (0-23 ft. tall), medium (23-46 ft.) and large trees were 67, 75, and 55 respectively. For grand fir the percentages were 55,85,and 76. Of the trees that had been top-killed, the average percentages of total tree height killed was 8, 7, and 4, for small, medium, and large Douglas-firs, respectively, and 4,4, and 4 for grand firs. Heavily damaged stands that were sampled had were composed primarily of Douglas-fir with little or no grand fir. The percentages of small, medium, and large Douglas-firs top-killed were 86, 70, and 83, respectively; the percentages exhibiting bare top were 95, 92, and 90. The percentages of total tree height top-killed were 9, 8, and 6 for small, medium, and large trees, respectively; for bare top these percentages were 32, 28, and 16. This suggests that the amount of topkill has increased after the 1986 defoliation, and will increase more if there is additional defoliation in subsequent years.

Under this Alternative, the maximum amount of top-kill and deformity caused by a full-term budworm outbreak would be experienced.

2. Alternative 2 - Direct Suppression with B.t.

Top-kill and deformity due to budworm damage, as described in Alternative 1, could be averted under this Alternative in stands which have not yet experienced top-kill. In those stands which already have budworm-caused top-kill, the amount of additional top-kill could be decreased.

e. Seed Production

1. Alternative 1 - No Action

Western spruce budworm infestations will cause damage to Douglas-fir, grand fir, and western larch cones, but the extent of this damage is unknown. In Montana, heavy budworm infestations have resulted in total failures of Douglas-fir seed crops, resulting in a lack of natural Douglas-fir regeneration in areas that suffered budworm-caused tree mortality (Dewey 1969, 1972). Reardon et al. (1984) found that budworm caused visible damage to about 98 percent of the Douglas-fir cones in an area with high budworm populations.

Under this Alternative, the forests would exhibit reduction in seed production which can be attributed to a budworm outbreak which is allowed to continue until it collapses naturally. Natural regeneration of the host species would be reduced during the outbreak.

2. Alternative 2 - Direct Suppression With B.t.

Application of B.t. to the infested areas could avert much of the budworm-caused seed damage and, thus, seed production would be greater than that under the No Action Alternative. The chances of establishing stands through natural regeneration would be increased.

2. Potential Effects on Water Quantity and Quality

a. Alternative 1 - No Action

Concerns have been raised regarding the effects of the budworm infestation upon water quality and quantity. Some feel that the defoliation and tree mortality influence snowpack levels and seasonal snow-melt.

Forest canopies do have a direct influence on snowpack and time of melt. In the analysis areas, seasonal runoff is significantly nfluenced by canopy condition. A study by Trondle and Gary (1982) shows that timber stand densities influence snow depth, water equivalents, and the timing and rate of snowmelt. He asserts that greater water yields are a result of small clearcut patches, strips, or blocks. Helvey and Tiedemann (1978) studied the effects of tussock moth defoliation on the timing and quantity of streamflows in the Blue

Mountains of Oregon. They studied three watersheds where defoliation ranged from 13 percent to 25 percent. While greater annual runoff was noted in the watershed with 25 percent defoliation, they concluded that variability of runoff prior to defoliation had also existed and that it could not be inferred that this runoff was caused totally by the defoliation. No changes in annual runoff were detected from the other watersheds, and no effect of defoliation on peak discharge was detected in any of the watersheds. Bethlahmy (1974) concluded that 30 percent total tree mortality caused by bark beetles resulted in increased streamflows on a Colorado watershed. Potts (1984) found that a total tree mortality of 35 percent associated with a pine beetle infestation in Montana apparently produced a 15 percent increase in annual water yields. No effects on peak discharge were detected; however, annual runoff began 2 to 3 weeks earlier than the "normal" dates indicated by pre-infestation records.

A study by Hicks (1977) of the effects of tussock moth defoliation upon water quality on the Umatilla National Forest concluded that there were no statistically significant differences between control and defoliated areas. Spruce budworm defoliation in initial stages affects only the current year's growth, whereas tussock moth defoliation generally involves all foliage. Additionally, tree mortality from tussock moth infestations is much greater than that associated with spruce budworm. These differences, usually resulting in less than 25 percent total defoliation, and only scattered mortality, indicate that total runoff or peak flows will not be significantly affected by the current spruce budworm infestation.

From this, it may be inferred that little potential for increased streambank cutting and increased stream sediment loading exists.

The no action alternative will have minimal impacts on water quality and quantity. It is not anticipated that the total defoliation of any watershed would be greater than 25 percent, therefore, no increase in annual water yield is expected. If total defoliation did exceed 25 percent, however, annual water yields could be expected to increase, but peak discharges should not increase. Without increases in peak discharges, no adverse impacts on bank stability or sediment loads are expected. Defoliation would slightly reduce streamside shade along some drainages, but stream temperature should not increase significantly. This alternative would have the least impact upon water quality and quantity.

b. Alternative 2 - Direct Suppression With B.t.

B.t. spores are found naturally in a number of environments, particularly in soils, where large populations of lepidopterous larvae exist, and in stored grains (Dulmage 1980). Studies have indicated that sunlight rapidly destroys the spores of B.t. (Cantwell and Franklin 1966) and that moisture, such as high humidities or rainfall, further reduces the viability of the spores (Pinnock et al. 1971, 1974). Endospores of B.t. can, under favorable conditions, remain dormant in the soil for considerable periods of time. Hitchings (1967)

found B.t. to remain active in the soil for at least 4 months. Buckner et al. (1974) studied the fate of B.t. in water following aerial applications in Canada. Their data indicate that B.t. will not persist in aquatic systems. Viable spores in river water and clams had completely disappeared within 4 weeks. Inference can be made, from evidence that moisture reduces the viability of spores, that aquatic systems do not provide a suitable habitat for the bacilli.

The formulations of B.t. being considered for use contain substances classified as "inert" ingredients. The exact substances and formulations are trade secrets closely protected by manufacturers. These "inert" ingredients are included in a listing (40 CFR 180.1001) by the Environmental Protection Agency (EPA) of all such substances considered safe for use in pesticide formulations. Dipel, one formulation, contains a mineral oil used as a suspension medium that would be considered such an ingredient. Thuricide, another formulation, does not contain a mineral oil, but has a suspension medium which is included in the EPA list. Water is the carrier (diluting agent) used for both of these B.t. formulations. Spreader/sticker agents are not planned for use. The use of adjuvants may be considered when necessary to increase probability of successful results; that is when it is necessary to spray under less than the most desirable conditions.

Small amounts of B.t. will probably get into municipal and other domestic water sources that are within treated analysis units. Over the whole infested area, this includes three municipal watersheds and numerous small domestic water sources, as mentioned in Chapter III of this EA. B.t. spores should be undetectable in about four weeks from the application date. No adverse effects to humans or other animals that use water from these sources are expected.

Implementation of Alternative 2 would reduce defoliation, and therefore, eliminate the slight impacts described for the no action alternative. Slight benefits associated with maintaining shade along streams would result from treatment. Treatment of the streamside zones with B.t. would introduce B.t. into the water. Concentrations from drift or actual overspraying would be far less than those levels which were tested and shown to have no effects. Application with aircraft would still involve the risk of spills of B.t. and aircraft fuel. Spills would present contamination problems in domestic or municipal water supplies. The effects would be of short duration until dilution and/or cleanup procedures took place.

3. Potential Effects on Terrestrial Wildlife and Domestic Livestock

In field tests of B.t., no adverse effects on mammals, birds, fish, aquatic invertebrates, or on predaceous or parasitic insects have been observed. Extensive laboratory tests have produced no evidence tha B.t. is pathogenic to vertebrates that inhale, ingest, or come in contact with it. See Appendix B for further discussion of these tests and conclusions.

a. Alternative 1 - No Action

Depending upon its extent and severity, budworm-caused timber stand defoliation has the potential to adversely affect big-game habitat. Rocky Mountain elk and mule deer use dense timber stands as hiding and thermal cover. These stands, if significantly affected by spruce budworm defoliation, could lose the characteristics of cover. Thomas and Leckenby (personal communication, 1984) felt that tree canopy closure was not significantly affected in most areas of defoliation. Spruce budworm defoliation characteristically occurs in the uppermost parts of the tree crowns, whereas the basal portion of the crown (which is damaged the least by budworm feeding) determines the percentages of crown closure in a stand and, therefore, the stand's value as thermal cover. Thomas and Leckenby felt that loss of thermal cover would not be significant. They also felt that, although some hiding cover would be lost, the amount would not be significant, and increased forage production in the affected areas would compensate for cover losses when determining overall habitat effectiveness. Thomas (personal communication, 1985) felt that no economic values could be assigned to these cover losses due to the offsetting factors. Economic evaluations of budworm impacts upon big game hiding cover in Montana have been included in a recent environmental assessment on the Gallatin National Forest. Review of that process indicates that, because of differing stand characteristics and basic assumptions about tree mortality in the Oregon and Washington infestations, the process used in Montana is not considered applicable to this environmental assessment.

Extensive, long-duration spruce budworm infestations provide insectivorous birds and mammals an abundant food supply. Localized areas have experienced large population increases in some species in response to this abundant forage. It is not known however, whether the total predator populations respond proportionately to increased budworm numbers or whether individuals are drawn into an area by the greater foraging opportunities. Arthropod predators of spruce budworm are also provided abundant prey. Again, there is no indication that these populations respond proportionately to the increased availability of spruce budworm as prey (Torgersen, personal communication, 1983).

Spruce budworm infestations and resultant top-kill and tree mortality provide slight benefits to cavity-nesting species and those species using spike tops as perches (Bull, personal communication 1984). Benefits were considered only slight because tree mortality usually occurs in trees less than 10 inches DBH. These small-diameter trees are most often unsuitable for cavity nesters.

Taking no action and, therefore, allowing continued spruce budworm infestation will result in minor reductions of hiding cover and thermal cover for big game. Offsetting these losses will be an increase of forage production associated with reduced tree crown cover. Both effects are considered to be of little consequence.

Beneficial effects of the infestation include slight increases in nesting habitat for cavity nesters and perches for raptors as a result of tree mortality and top-kill. The abundant insect populations are also beneficial to insectivorous wildlife species. These benefits of abundant forage are transitory, lasting only as long as the current infestation.

Overall, it appears that general wildlife populations benefit slightly from the current spruce budworm infestation. Benefits are transitory, however, and would not be expected to last much longer than the infestation.

Domestic livestock could benefit slightly from defoliation and resultant increases in forage production.

b. Alternative 2 - Direct Suppression With B.t.

The impacts upon wildlife resulting from increased human activity are associated with any treatment project. Coverage of large areas by personnel and equipment increases the disturbance factor for wildlife. Species sensitive to this type of disturbance, such as bald eagles, golden eagles, ospreys, and spotted owls, nest in some analysis units (see Section IV, Affected Environment). These birds could abandon nests because of disturbance by low flying aircraft or activities of ground personnel. Concerns about the effects of an ongoing project on deer, elk, and bighorn sheep have been raised; some feel lactating mothers may abandon their young. Additionally, some are concerned that the young would be more vulnerable to predation. Thomas and Leckenby (personal communication, 1983) felt that the potential for such an effect exists but, due to the limited duration of disturbance in each spray block, significant impacts were unlikely.

Field tests have not revealed any deleterious effects of B.t. on populations of birds and mammals. In studies in Algonquin Park and Spruce Woods in Canada, no significant differences were found between the populations of birds and mammals on the sprayed plots vs. the populations on the unteated plots (Buckner et al. 1974). In a second test, aerial application of B.t. (Dipel WP) applied at a rate of 0.5 lb./acre to a Scotch pine plantation containing a large population of nesting mourning doves apparently did not affect or disturb the birds (Kearby et al. 1975). Twenty-four hours after spraying, nestlings were observed still in their nests and adults were flying about the plantation. After 28 days, adults were still numerous and nestlings had fledged. In 1986, a study was done to determine the secondary effects of B.t. spray on chickadees during the 1986 Gypsy Moth Project in western Oregon (Gaddis and Corkran, 1986). Spray areas were treated three to four times with 16 to 20 BIU's per acre. Results indicated that there was a significant difference in the number of lepidoteran caterpillars available for food between treated and untreated areas; however, this did not affect chickadee reproductive success or fledging development; chickadees simply found other food. There was no significant difference in time spent foraging for food between treated and check areas. In another study conducted by the Oregon State Fish and Wildlife, clutches of pheasant eggs received simulated applications of B.t. spray. There was a significant decrease in

egg hatch between treated and nontreated eggs (unpublished report). B.t. applications with and without the enzyme chitinase had no detectable impact on small mammal abundance (Buckner et al. 1974). Field mice (Napaeozapus insignis Miller and Peromyscus maniculatus Wagner), shrews (Blarina brevicaudia and Sorex cinereus Kerr), voles, and chipmunks (Tamias striatus L.) were examined and 80 percent of a small sample of adult females had placental scars, indicating that reproduction was unaffected.

Extensive laboratory testing of the effects of B.t. upon wildlife and domestic species has been accomplished. The results of these tests have been published in the following documents:

"Environmental Assessment Western Spruce Budworm Management in Northeastern Oregon", Appendix F, USDA Forest Service, Pacific Northwest Region, 1984;

"The Toxicology Profile", Abbott Laboratories, 1982;

"Gypsy Moth Suppression and Eradication Projects Final EIS", USDA, March 16, 1984.

"A comprehensive review of Bacillus thuringiensis var. kurstaki" by J.F. Sassaman, 1987.

Except for lepidopterans, no toxicity to zooplankton, arthropods, fish, birds, mammals, and other wildlife or domestic species has been demonstrated at levels recommended for field application. In fact, only at extremely high concentrations (such as might occur with a spill) has any effect been demonstrated.

Concern has been expressed by livestock operators about the use of bacteria in areas where their livestock graze. B.t. has been identified only once as a pathogen in mammals, being reported as the causal agent in a case of bovine mastitis. Whether other factors were involved in this case is not known (USDA Forest Service/Animal and Plant Health Inspection Service, 1984).

It is evident from laboratory testing of the effects of ingestion upon domestic species that B.t. will produce no adverse effects, and even if ingested in large quantities the organism will not survive in the animal's system. Regulatory agencies have placed no restrictions on the use of B.t. near livestock or food crops. B.t. has been widely used to control insect pests other than western spruce budworms. In the case of formulations used for gypsy moth suppression and eradication, B.t. is a lepidoptera-specific insecticide; therefore, only phytophagous insects in the Order Lepidoptera (butterflies and moths) are affected. In field tests in Nova Scotia where B.t. was the only insecticide applied to an apple orchard over a 4-year period, population levels of lepidopterous insects were reduced, but there was no observed effect on predaceous insects (Jaques 1965).

Spruce-fir stands in Algonquin Park, Ontario, Canada and mixed forest containing mature spruce stands, poplar bluffs, and areas of dense brush and open fields in Spruce Woods, Manitoba, were sprayed with formulations of Thuricide 16B or Dipel WP (trade names of B.t. formulations). Although some declines in populations of non-target insects were observed, comparison with the controls indicated that the declines could not be attributed to the spraying (Buckner et al. 1974). These studies also reported no significant increase in mortality among foraging bees as a result of B.t. treatment. Many other studies of the effects of B.t. on honey bees (Krieg 1962, Krieg 1963, Burges and Bailey 1971, Franz et al. 1967, Cantwell et al. 1966, Wilson 1962) found no evidence that these insects would be harmed by B.t. at the levels commonly used in spray operations. B.t. has been shown to be non-toxic to bees at levels as high as 726,000 spores per bee (Atkins et al. 1975).

One study has shown B.t. to be fatal to earthworms at concentrations 104 to 105 times higher than that which would occur in the soil after normal application in the field (Smirnoff and Hempel 1961). However, these studies were carried out using B. thuringiensis var. thuringienesis, a producer of beta-exotoxin which could have influenced the results. In experiments using Dipel (16,000 International units/mg) at dose rates of 60, 600 and 6,000 mg/square meter on forest plots and Bactospeine (1000 IU) at a dose rate of 30 g/cubic meter, worm density after spraying was not significantly different from worm density prior to spraying (Bentz and Altwegg 1975). The formulations considered for use against spruce budworm contain a variety of the B.t.bacterium that does not produce beta-exotoxin.

Other concerns associated with a B.t. spray project center around the impacts upon non-target lepidopterans and the impact that a reduction of lepidopteran populations will have upon species that prey upon these insects. Many butterflies and moths will have pupated or completed metamorphosis prior to the proposed early summer budworm treatment period. Also, only those phytophagous larvae that feed on external plant parts will be susceptible to B.t. Those insects that feed inside plants such as borers, needle miners, and gall moths will not be affected. Additionally, under the most favorable conditions for control, a percentage of insects, even target species, survive control efforts. In a study done during the 1986 Gypsy Moth Project in western Oregon, it was found that the population of lepidopteran larvae was reduced significantly within 48 days following the last treatment. However, there was no significant difference between populations in the control and treated areas 68 days following the last treatment (Miller 1986). Considering these combined factors, it is highly unlikely that significant impacts upon non-target lepidopteran populations will occur or that there will be significant adverse impacts upon predatory species using lepidopterans as a food source. Effects of B.t. on butterflies and moths associated with dwarf mistletoe is unknown.

Complete listings of laboratory tests on various animals can be found in Appendix B.

Since B.t. is not a broad-spectrum insecticide and it affects only lepidopterans (moths and butterflies) , expected impacts upon terrestrial organisms are slight. Most beneficial insects would not be affected. Some non-target moth and butterfly species which are in the larval stage at the time of treatment may be at risk of experiencing slight population reductions for a year or two. Species of special interest are listed in Chapter III of this EA. Insect populations representing food supplies for birds would not be appreciably affected, so the risk of nest abandonment would be slight.

Implementation of Alternative 2 would result in minimal disturbance of wildlife populations. This disturbance, as it relates to survival and abandonment of young, would have little adverse impact. Mitigation measures controlling the timing of treatment and no-treatment buffer zones around critical areas such as bald eagle nests or bighorn lambing areas will minimize disturbance.

A number of vertebrate wildlife species will be exposed to some level of B.t. under this alternative. Species, including those of special interest, that are known or suspected of occurring in at least one analysis unit are listed in Chapter III of this EA. None of these species will experience serious adverse effects as a result of exposure to B.t.

4. Potential Effects on Aquatic Invertebrates and Fish

a. Alternative 1 - No Action

Most data indicate that even with heavy infestations of spruce budworm, most tree defoliation would be less than 100 percent and stem mortality over the outbreak area would be less than 3 percent. Given these values, it is unlikely that water temperatures of streams in affected areas will be significantly altered. Therefore, no effects on fisheries resulting from water temperature increases are expected. Low levels of tree mortality in riparian areas have the potential to add organic debris to streams and, thereby, enhance fisheries habitat. Sedell and Luchessa (1981) pointed out the importance of organic debris in streams in relation to fisheries habitat.

Budworm larvae falling into streams in areas of heavy infestation could enhance food supplies and beneficially affect growth rates of fishes.

The no action alternative, having minimal adverse impacts on water quality, would have similar minimal effects on fisheries. Minor amounts of streamside shade could be lost. Tree mortality occurring in the streamsides would add woody debris to fish habitat providing cover and pools. Fish populations would benefit from such habitat improvement. Aquatic invertebrates would not be affected by the no action alternative. This alternative would have the least impact or risk of impact upon aquatic invertebrates and fish.

b. Alternative 2 - Direct Suppression With B.t.

Few toxic effects have been reported in studies of aquatic species exposed to B.t. While monitoring aquatic species on Moresby Island, British Columbia in 1960, Todd and Jackson (1961) found no adverse effects on coho salmon fry or on aquatic insects in streams within an experimental area treated with B.t. In studies in Algonquin Park, Ontario, Canada, fish and bottom fauna suffered no adverse effects up to 4 weeks after spraying (Buckner et al. 1974). Ignoffo (1973) found B.t. to be toxic to coho salmon only at high concentrations that would be found following a direct spill into a stream.

Several acute toxicity tests conducted on fish are reported by Fisher and Rosner (1959). A 4-day toxicity study was conducted with B.t. on rainbow trout and bluegills in which two groups of ten fish each were placed in water containing B.t. at concentrations of 560,000 and 1,000,000 parts per billion (ppb). None of the trout or bluegills died (Fisher and Rosner 1959). Rainbow trout that were 4 inches long were exposed to B.t. at concentrations of 100,000 to 1,000,000 ppb for 14 days. No deaths resulted, nor were symptoms of alimentary or behavioral disturbances evident (Fisher and Rosner 1959). In a test with juvenile coho salmon (1.6 inches long), B.t. was shown to be about 1/30 as toxic as DDT. The test ran for 168 hours with concentrations of 8,000 to 406,000 ppb. The 48-hour median tolerance limit of the B.t. was about 50,000 ppb (Fisher and Rosner 1959). In other words, for 48 hours, 50 percent of the fish tested tolerated a B.t. concentration of 50,000 ppb with no observable adverse effects.

Other toxicity test results are listed in the chemical profile for B.t. contained in the Environmental Assessment Western Spruce Budworm Management in Northeastern Oregon, Appendix F. 1984 (1984 EA). A summary of these data indicates no reason to suspect impacts upon aquatic fauna other than aquatic lepidopterans and selected dipterans (flies). Aquatic moth species belonging to the family Pyralidae are not known to occur within the analysis units. Blackfly larvae (Simuliidae), in a study by Eidt (1985), demonstrated susceptibility to Bacillus thuringiensis var. kurstaki (B.t.k.) in concentrations of 430 International Units/liter. B.t.k. has also been tested and found to be more or less toxic to several species of mosquitos (Krieg and Langenbruch, 1981). Two crustacean species in the genera Daphnia and Cyclops, and a mayfly species, Picromerus bidens were tested in Eidt's study and shown to suffer no effects from B.t.k. Other varieties of B.t. have also demonstrated toxicity to some species of mosquitos and blackflies. Bacillus thuringiensis var. kurstaki is the variety being considered in this analysis.

Unlike chemical insecticide testing which often produces widely varying results, the testing of B.t. has proven to be more consistent in its effects upon non-target organisms. As a result, B.t. is used in the East without extensive monitoring programs. The study by Eidt (1985) demonstrating no toxicity to mayfly, stonefly, and caddisfly larvae and toxicity only in high concentrations (430 International Units/liter) to blackfly larvae has resulted in a policy change. New Brunswick regulations no longer require stream and lakeside buffers when using

B.t. field applications where worst-case scenarios project concentrations of less than 4.3 International Units/liter. Therefore, the concentration of 430 International Units/liter represents a value 100 times greater than that which would be expected in a direct application to water.

B.t. treatments in the streamsides would pose no threat to aquatic organisms unless a direct spill occurred. Concentrations in streams resulting from normal treatment would be far below the levels that proved toxic to blackfly and mosquito larvae. The adverse effects of spills would be short term and limited to relatively small stream reaches.

The risks of spills and the subsequent contamination of water with fuel and/or large quantities of B.t. is very low.

5. Economic Efficiency and Local Impacts

a. Introduction

Western spruce budworm infestations are a natural component of the biological environment of western coniferous forests, and their sporadic occurrence can, over time, alter the forest resource characterisitics. This impact, in turn, can influence the flow of future forest resource outputs. The flow may be reduced or enhanced at various points in time depending on the severity of the infestation and the type and condition of the resource being affected.

Forest resources are managed to produce outputs that are beneficial to society, so protection of the resources and the flow of outputs is necessary. The level of protection provided from forest pests is a resource allocation decision. This decision must weigh the social benefits of minimizing undesirable resource impacts against the social costs of resources expended by protection measures and of any adverse economic, social and environmental effects.

One purpose of the economic analysis is to value identified and quantified effects (both benefits and costs) resulting from an infestation, whether or not the outbreak is treated. Economic effects may be expressed in either dollar or nondollar values and can be classified into two categories: real and pecuniary (Musgrave and Musgrave 1973). Both categories have a benefit and cost dimension.

Real effects refer to those impacts that have the potential to change the material well-being of society, such as the loss of standing mature timber or fish habitat. Of interest here is the identification and social valuation of material resources expended (cost) and resources preserved or produced (benefits) by a pest management activity.

Direct control is considered economically efficient when benefits that can be valued exceed costs of suppression. The ratio of benefits to costs (benefit-cost ratio) is used to compare the relative cost efficiency of treating alternative analysis units. Units with benefit-cost ratios greater than 1.0 are considered cost efficient investments. The larger the benefit-cost ratio exhibited by an analysis unit the more attractive is the investment opportunity.

A pest management alternative will also result in both short-term and long-term local economic impacts. These are typically measured by changes in income, earnings, employment, output, and other economic and financial conditions.

Local economic impacts reflect both real and pecuniary effects. Pecuniary effects are benefits and costs that accrue locally but occur at the offsetting expense or gain to other locations. By definition, they do not contribute to the "material" welfare of society as a whole, although they may be socially desirable. Rather, pecuniary effects reflect shifts of material well-being from one part of society to another and between individuals and locations. Society's concern with an equitable distribution of benefits and costs and the impacts of changing levels of economic activity on local and regional communities often necessitates an examination of pecuniary effects. Changes in wage rates, income, earnings, employment, output, and price levels are frequently used to measure pecuniary effects and local economic impacts. Also, positive pecuniary effects or local impacts may result regardless of whether or not an alternative is economically efficient.

b. Methods

The methods used to quantify and value changes in forest resource output flows and other information pertinent to the economic analysis are elaborated in Appendix C. These methods are specifically tailored to valuing the resource effects identified in the Environmental Consequences section of the EA. For each analysis unit, the alternatives considered in the EA are assessed for relative economic efficiency by examining the relationship between their respective predicted benefits and costs. Economic efficiency criteria are presented to assist decisionmakers in selecting units for application of a pest management alternative (which includes the possibility of 'no action).

In some instances, insufficient information exists to quantify the immediate biological effects of the infestation or treatment measures, and there is no methodology for projecting eventual resource output changes. Hence, there is no basis for evaluating the economics of these biological effects, and the implications of these situations only can be considered in a qualitative manner.

c. Alternative 1 - No Action

Under the No Action Alternative, a long-term reduction in the future supply of fiber is projected for most analysis units. Some areas of the infestation may experience small areas of substantial mortality. To the extent that this leads to timber salvage sales and subsequent processing of timber, local economic activity will increase over the short-term.

The No Action Alternative entails no investment expeditures in direct control. Hence, there results no benefits in terms of averted losses. The economic loss associated with inaction is the benefit to be ascribed, in part or whole, to an action alternative.

d. Alternative 2 - Direct Suppression with B.t.

To the extent funding is available, investment in direct suppression with B.t. will be made in analysis units exhibiting the greatest net financial and intangible benefits. Appendix C displays the measureable net benefits associated with direct suppression of each analysis unit. Total net benefit accruing to this alternative is a measure of economic efficiency which indicates an improvement in the nation's material well-being.

Direct suppression will also lead to various economic impacts. In the short term, project expenditures in regional and local trade, services, and other economic sectors will bolster economic activity. Over the longer term, a pest management alternative will ensure the future availability of a greater supply of timber for the local processing industries. This result will set the stage for higher levels of future local economic activity which, in turn, will produce other beneficial regional and community impacts.

6. Potential Human Health Hazards

a. Alternative 1 - No Action

Under this alternative, the hazards to human health would change very little from those encountered during the normal forest management operations. In stands which incurred a high level of tree mortality, the hazards to people working or recreating would increase slightly as snags began to deteriorate and fall.

b. Alternative 2 - Direct Suppression With B.t.

1. Introduction

The following paragraphs address the concerns about possible long-term, short-term, or cumulative effects to human health from the use of the insecticide Bacillus thuringiensis (B.t.). (A more detailed discussion is in Appendix B, Pesticide Background Statement - Bacillus thuringiensis).

Bacillus thuringiensis is registered under various trade names by the Environmental Protection Agency (EPA) for use on forest sites to suppress populations of defoliating insects. Bacillus thuringiensis was developed in the 1960's, and is produced and marketed by several manufacturers. The kurstaki variety of B.t. is insecticidal only to lepidopterous (moth and butterfly) larvae. Its low toxicity to other life forms and its relative effectiveness against target populations have resulted in greatly increased use of B.t. in recent years for insect suppression.

Segments of the public have concerns and anxieties about insecticide use because they feel that these substances either pose an immediate human health hazard or that insecticides have a capacity to cause health problems in the future. These feelings arise from an unfamiliarity with what is known about the insecticides, a distrust of the science which demonstrates their effects (and in some cases, of the organizations doing the analysis), or a belief that not enough is known about the properties of the insecticide.

2. Product Registration

The EPA makes the ultimate determination of an insecticide's basic safety, i.e., whether a product should be marketed and used in this country. The EPA has a legal responsibility to assess all toxicological data available to determine if a pesticide may be used for its intended purpose and in a manner prescribed without posing an unreasonable risk to the environment or humans. In the latter half of the 1970's and until 1983, EPA utilized a process known as Rebuttable Presumption Against Registration (RPAR) to assess the risk of using a pesticide if evidence existed that the pesticide caused an adverse effect (trigger) in one of the five following critical toxicological and environmental areas:

a. Acute toxicity

b. Chronic toxicity

    1. Oncogenic (tumor producing)

    2. Mutagenic (mutation causing)

c. Other chronic - Reproductive

    1. Fetotoxicity (toxic to a fetus)

    2. Teratogenic (causing birth defects)

d. Significant reduction in wildlife, reduction in endangered species, and reduction in nontarget species.

e. Lack of emergency treatment or antidote.

The RPAR process involves several stages. First, after identifying one of the triggers, EPA begins a review of all known information about the pesticide. The information is scrutinized; more tests of the pesticide performed (if needed); exposure; hazard and benefits assessed; and a decision rendered. EPA's decision could fall within a full range of regulatory options available, from full registration to complete cancellation, at any time during the RPAR process. The currently-used process known as Special Review provides a role similar to RPAR in the agency's responsibility for monitoring and review of chemical toxicity information.

B.t. has not been through the RPAR or Special Review process. However, the relevent toxicological data has been evaluated by EPA, and the material was determined not to pose an unreasonable risk to humans when used as directed.

3. Summary of the B.t. Background Statement

The B.t. Background Statement presented in Appendix C reports incidents involving possible human toxicity. Ten days after a worker accidently splashed a suspension containing B.t. in his face, the individual developed a corneal ulcer. Although a bacillus resembling B.t. was identified in cultures taken from the corneal ulcer, medical opinion seems to question the involvement of B.t. (J. B. Curry, personal communication, 1985).

A review of recent information which has become available since the Background Statement was compiled reveals the following:

R. E. Warren et al. (1984) reported a clinical infection caused by Bacillus thuringiensis israelensis, a variety related to B.t. Berliner, and is commonly used for mosquito control. A research student accidently stuck a needle contaminated with spores and endotoxin into the webspace between his fingers. The finger became discolored and swollen, and lymphangitus developed despite treatment with antibiotics. The individual recovered from the soft tissue infection after 5 days.

Abbott Laboratories supplied information (J. B. Curry personal communication, 1985) related to the safety of B.t. for occupationally exposed workers. Monitoring of exposure levels in the fermentation area reveals that B.t. spore counts ranged from 10,000 to 100,000 cells per cubic foot from 1970 to 1977, and averaged approximately 1,000 cells per cubic foot from 1977 to present. These exposure levels to workers far exceed the exposure to applicators or to the general public. Employees undergo complete physical examinations at least annually. No symptoms attributable to B.t. have been observed in any of the 31 employees, some of whom have worked in the area for at least 14 years. Employees wear no protective gear other than safety shoes and hardhats. This would indicate that chronic ocular, inhalation, and dermal exposure to B.t. causes little risk for adverse effects in humans.

Procedures to evaluate health effects related to B.t. use on the 1985 Gypsy Moth Control Project in Oregon were established by the State Health Department and the Lane County (Oregon) Health Department. The State cultured tissue and fluid from exposed individuals with pre-existing wounds. While data analysis is not complete, 37 of 54 samples have tested positive for the presence of a Bacillus organism. It was determined, through a set of screening criteria, that only three of those cases could have any relation to the Gypsy Moth Project. Similar follow up procedures were done during the 1986 Gypsy Moth Project, and of the 13 cases testing positive to the presence of a Bacillus, none met the criteria as possibly associated with the Gypsy Moth Project. None of these confirmed infestations have resulted in infections. The public

was invited to report suspected health problems during the project. In 1985, the County reported receiving a number of complaints from area residents for effects such as itchiness, nausea, headache, rash, laryngitis, or watery eyes. Individuals were then invited to follow up on symptoms with their personal physicians. On these reported cases, it has been impossible to verify or establish a connection to B.t. exposure since there was no followup clinical analysis.

4. Risk of Exposure

Exposure to insecticides may be either voluntary or involuntary. Voluntary exposure occurs to people actively participating in a suppression project. Involuntary exposure involves people who are in the area during treatment and are unaware that a project is in progress, people who visit the forest after treatment and come in contact with pesticide residues, or people who use unknowingly use water from sources which have been contaminated with B.t.

A major variable in the potential human exposure (population at risk) is the number of people present in the project vicinity. While risk of an occupational (voluntary) exposure is more or less constant, the risk of exposure to the general public is related to population numbers. Mitigation measures (posting and notification) provide a good deal of control over exposure risk to the general public. The public will be notified through local news media when and where spray operations will occur. Treatment areas will be posted with signs giving dates of spraying and contacts for further information. Project personnel will inform Forest visitors as they are encountered in areas to be sprayed.

A characteristic common to all spruce budworm analysis units is a relative remoteness from population centers and residential areas. This remoteness becomes apparent when the budworm project area is compared to the large gypsy moth suppression and eradication efforts located in the northeastern United States. The population density in even the rural settings on the gypsy moth projects is estimated to be 0.2 people/acre or one person per 5 acres. (USDA-FS/APHIS 1985). This density may be compared to an average of one person per 75 acres found on the National Forest portion of the budworm project area. The estimate of people per acre includes residents within or adjacent (within 1/4 mile) to Forest boundaries, plus the recreational use (including firewood gathering) within each National Forest. (Data source is USDA Forest Service, Pacific Northwest Region).

In summary, the risk of exposure to B.t. varies slightly between the analysis units. The risk of occupational exposure to project workers is relatively constant, although this risk is also a function of logistical characteristics within individual units (such as size of organization, physiography of the area, communications limitations, amount of pesticide movement, and handling). The potential for exposure to the general public (population at risk) is directly related to numbers of people in or near the area being treated. The possibility of direct exposure is low. Since operational use of B.t. in the past has shown little or no evidence of serious adverse human health effects, it is concluded that even in analysis units with the highest risk of general public exposure to B.t., the hazard to human health is very low.

7. Uncertainties in Achieving Lasting Spruce Budworm Population Reduction

a. Alternative 1 - No Action

The use of the no action alternative has little effect on the uncertainties of achieving lasting budworm population reductions. In areas where the No Action Alternative is selected, the current outbreak would be allowed to run a natural course of rise, peak, and decline. Weather, parasites and predators, diseases, and food supply would be allowed to exert their normal control over the current outbreak cycle. Use of this alternative does not exclude the long-range prevention of budworm outbreaks through current and future forest management practices.

b. Alternative 2 - Direct Suppression with B.t.

1. Introduction

Because of uncertainties about western spruce budworm behavior and population dynamics, the ability to achieve a lasting reduction in budworm populations is a concern. Gathering precise information about factors affecting populations before and during an outbreak is a slow and difficult process because the budworm has broad ecological tolerance limits. Each new outbreak provides more information about the budworm and how it interacts with its environment. Such information is vital to making wise decisions when selecting management alternatives during an outbreak and developing ways to prevent future outbreaks. When information is lacking, the uncertainties must be identified and evaluated in order to make the best selection from a range of alternatives. The following discussion addresses four categories of uncertainties identified during scoping for this analysis:

What controls an outbreak of the western spruce budworm and will treatment affect the natural cycle of an outbreak?

Will the budworm reinfest treated areas from adjacent untreated areas?

Since project goals do not call for total eradication, will budworm populations, reduced by treatment, build back up to damaging levels or remain low for the remainder of the outbreak?

Can the budworm, over time, develop population resistance to insecticides?

2. Outbreak Cycle

Dramatic increases in an insect population can be the result of a wide range of factors. A change in weather, food quantity and quality, or biological enemies can separately or together cause an outbreak of a particular species. Two conditions currently believed to cause outbreaks of the western spruce budworm are an abundant food supply (extensive stands of Douglas-fir and true firs) and favorable weather (Fellin et al. 1983).

Human intervention in the ecosystem through timber harvesting practices and control of wildfire has led to large acreages of true fir and Douglas-fir (West 1969, Hall 1980, Schmidt 1981). This readily available food source, combined with favorable (warm and dry) weather during May, June, and July, can lead to an outbreak (Hard et al. 1980, Ives 1981, Twardus 1982). Natural enemies such as parasites and predators, both vertebrate and invertebrate, apparently exert little control over budworm populations moving into an epidemic situation (Miller and Renault 1976, Ives 1981, Campbell and Torgersen 1982, Torgersen et al. 1984). Natural enemies exert their greatest pressure on budworm populations at endemic levels and during the last stages of an outbreak decline. Weather and, in some cases, starvation appear to be the most important factors resulting in the decline of an outbreak (Fellin and Schmidt 1973, Fellin et al. 1983).

Prolonging a budworm outbreak or increasing the frequency of outbreaks through the use of insecticides is potentially a problem but is insignificant in comparison to the proliferation of extensive areas of the preferred hosts (Blais 1983, Fellin 1983). The philosophy about using insecticides in western spruce budworm management has changed from ending an outbreak with one application to using a number of applications to provide the trees some respite from heavy defoliation (Fellin 1983). The protected food source in treated areas will remain available to support an outbreak, but with other mechanisms (such as weather) as the apparent controlling factors, the outbreak should eventually decline whether an area is treated or not.

3. Re-invasion

This uncertainty concerns the ability of the western spruce budworm to move into and reinfest treated areas from adjacent untreated areas. In the West, the budworm's pattern of both short-distance and long-distance movements is not known. The lack of techniques and the difficulty in accurately recording moth dispersal have been barriers to the study of adult movements. When disturbed, or upon encountering competing larvae, budworm larvae drop from branches on silken threads and can be carried by the wind to other trees. Movement by this means is generally over short distances (0 to 500+ feet), depending on the length of the thread, size of the larvae, distance above the ground, and wind speed (Batzer 1968). Small larvae, just out of the overwintering stage, could be carried for miles with favorable wind conditions. The importance of this larval "ballooning" in reinfesting large areas is probably low, due to the low chance of successful establishment of large numbers of the aerial-born larvae (Batzer 1968).

It is reasonable to assume, that in the absence of substantial geographic barriers or breaks in host-type, adult moths will move freely in their search for host plants. In past budworm control projects using DDT in Oregon and Washington, less than one percent of the areas have had to be retreated because of "re-infestation" (Dolph 1980). In other western regions, the number of areas needing retreatment has been higher (Fellin 1983). The treatment of smaller units (AU's) with adjacent infested but untreated areas has led to adopting a multiple-treatment scenario for the alternatives considered in this analysis.

4. Resurgence

The third uncertainty is whether budworm populations, reduced by treatment, remain at low levels or build back up (resurge) to outbreak numbers. In the Pacific Northwest, control of the western spruce budworm has generally kept populations at acceptable levels for the remainder of the outbreak (Dolph 1980). A reason for this success could have been the use of DDT, a more persistent chemical, over large areas in the 1950's. No resurgence was noted for the projects using carbaryl in the late 1970's. With the food source remaining available and continued weather conditions conducive to population build-up, it is reasonable to assume that, given enough time, populations could build back up to an outbreak level. The time required for buildup would be directly related to the control effort's effectiveness which is dependent upon the insecticide used, its dosage and coverage, the timing of application and the weather during and after application (Stock and Robertson 1984). The lower the budworm population densities are reduced, the higher the probability that the population will not resurge. It is expected that monitoring of control efforts taken in the current northeast Oregon outbreak, beginning in 1982, will provide information about this uncertainty. In the past control projects, treatments usually began at least 3 to 4 years into the outbreak. During the current outbreak, treatment began as early as the second year of visible defoliation. With this relatively early treatment, some population resurgence has been found, similar to the 1977 budworm control project in New Mexico (Telfer 1983). Smirnoff's (1983) biochemical analyses Showed that B.t. treatments had a detrimental effect on eastern spruce budworm vigor. Carbamate and organophosphate chemical insecticides encouraged the reurgence of vigorous populations as a result of stimulation of the budworm by sublethal dosages. It should be noted that in the East foliage protection is the objective of budworm control rather than population reduction. This strategy may result in more sublethal effects than a population reduction strategy.

5. Resistance to Insecticides

The development of resistance generally requires heavy selection pressure from the repeated use of a particular insecticide. However, selection pressure on only one generation may lead to a greater resistance in some cases (Robertson and Stock 1985, McGaughey 1985).

It is generally considered difficult for insects to develop resistance to microbial insecticides, such as B.t., because of their complex modes of action. One report, however, indicates that Plodia interpunctella, a lepidopteran pest of stored grain, has developed resistance to commercial formulations of B.t. within a few generations (McGaughey 1985). The report pointed out that the stored grain environment provides an ideal situation for resistance development. To develop a similar resistance in a field crop environment would require repeated applications over a wide geographic area for several years. Such a situation has not existed in the case of western spruce budworm treatments in the Northwest.

6. Summary

B.t. has seen relatively little operational use for western spruce budworm control compared to chemical insecticides. This lack of information about the insecticide precludes detailed analysis of the uncertainties of achieving lasting budworm population reductions. A few generalities apply, however. If B.t.'s record of variable effectiveness is due to the activity of B.t. and not the application method, its widespread use could only increase the risk of both resurgence and reinvasion. B.t.'s mode of action requires that it be ingested by the budworm larvae (Smirnoff 1979), and this lack of contact toxicity can lower the insect mortality rate. The water base formulation of B.t. (used to reduce the insecticide's environmental impact) may affect its effectiveness when it is applied during periods of intermittent rain. If the agent is partially washed from the conifer foliage, it cannot be ingested by the budworms.

A possible advantage in the use of B.t. is its potential for longer activity in the target budworm population and in following generations (Klein and Lewis 1966, Morris 1977, Smirnoff 1979). Some of the variation in budworm control noted in past studies could be related to the slower action of the bacteria in causing insect mortality; that is, some mortality may have occurred too late to be measured. Stipe et al. (1983) indicate some carry-over activity after the first year of treatment. In addition, larvae that are parasitized are usually more sluggish and do not feed as much as larvae that are free of parasites (Lewis 1960, Leonard and Simmons 1974, Hamel 1977). The need for B.t. to be ingested in order to act on the budworm could increase the success and survival of larval parasites.

8. Potential Effects on Threatened, Endangered and Candidate Species

a. Alternative 1 - No Action

Under this alternative there would be no change from the effects expected due to ongoing forest management operations.

b. Alternative 2 - Direct Suppression with B.t.

Bald eagle nesting territories may occur within several Analysis Units. A 1/2 mile radius buffer will be maintained around the nest sites. In addition, a set of mitigating measures developed with concurrence from the U.S. Fish and Wildlife Service will be incorporated in the Project Operations Plan and implemented during treatment that will result in no effect to nesting eagles.

A list of candidate species which may occur in some of the analysis units was also provided by the U.S. Fish and Wildlife Service. No effect from treatment is anticipated for these species.

The historic locations of known populations of threatened, endangered, and candidate plants on National Forest lands are kept on file. Access to this information is limited to prevent plundering by collectors.

These plants, which are located in applicable analysis units, may be affected to some degree by the application of some of the B.t. formulations considered in this analysis

The Macfarlane's four o'clock, federally listed endangered species, was provided as possibly occurring within some of the analysis units. Locations listed Township and Range show that it does not occur within any of the proposed analysis units, therefore, treatment would have no effect.

During B.t. spray projects in the Seattle, Washington area in 1983 and 1984 using Dipel 4L and Dipel 8L, respectively, some burning of new foliage on tender-leaved ornamentals and hardwoods, such as linden and vine maple, was noted. Effects were limited to the leaf area where a spray droplet actually landed and seemed to be a mechanical damage rather than chemical toxicity. The spraying occurred on sunny days, and on-the-ground personnel suspect that the mineral oil carrier tended to focus light at that point and burn the foliage beneath the droplet (LaGasa, personal communication 1985).

In areas planned for treatment, the project leader will coordinate with the Forest Service Area Ecologist and take appropriate action to assure that threatened or endangered plants are protected.

Annual plant species that are dependent upon insects for pollination would be adversely affected if pollinating insect populations were eliminated. However, no reductions in these populations are expected with B.t. treatments.

9. Potential Effects on Cultural Resources

a. Alternative 1 - No Action

Under this alternative, there would be no change from the effects expected due to ongoing forest management operations.

b. Alternative 2 - Direct Suppression with B.t.

The only ground disturbing activities that would be encountered under this alternative would be the possible establishment of new heliport sites within forested areas.

Before any ground disturbing activities occur, previously undisturbed and unsurveyed areas will be examined by qualified personnel for the presence of cultural resources. Appropriate protection measures will be taken for any cultural resource sites discovered to ensure that cultural information is not lost. The State Historical Preservation Officers in Oregon and Washington have been consulted.

10. Irreversible or Irretrievable Effects

a. Alternative 1 - No Action

No irreversible commitments of resources have been identified. There is an irretrievable net loss of timber (wood fiber) production associated with this alternative. This net loss is estimated to be 1.5 billion board feet (BF) or an average of about 933 board feet (BF) per

acre. This timber volume loss would be distributed over the next 70 years, assuming that harvest schedules do not change substantially from today's situation. This also assumes that no further budworm control projects are implemented for the duration of the current outbreak. If, for instance, a suppression project were to be initiated in 1988, only a portion of the projected net loss would be irretrievably lost.

b. Alternative 2 - Direct Suppression with B.t.

No irreversible commitments of resources have been identified. Implementation of the action alternative would avert most of the total net loss estimated under the No Action Alternative. Recouping 100 percent of the estimated loss could be accomplished only with a highly successful treatment program in 1988 which covered all of the 1.6 million acres analyzed in this EA.

Another view of the situation is to consider the budworm effects on timber production as a part of the baseline resource condition. From this baseline, budworm suppression projects represent investment opportunities. In other words, various portions of the estimated 1.5 billion BF volume at risk may be protected by investing various amounts of funds in a suppression program.

11. Short-Term Human Uses Affecting Long-Term Productivity

a. Alternative 1 - No Action

This alternative would involve no known short-term uses of the human environment that would affect long-term productivity of the resources.

b. Alternative 2 - Direct Suppression with B.t.

Treatment of infested areas with B.t. in 1988 would result in an increase of long-term productivity of wood fiber.

12. Energy Requirements and Energy Conservation Potential

a. Alternative 1 - No Action

The energy requirements and energy conservation potential would be unchanged from those expected due to ongoing forest management operations.

b. Alternative 2 - Direct Suppression with B.t.

Implementation of this alternative would involve consumption of fossil fuels to power aircraft and ground-based support vehicles. Other than minor savings possible through the "conservative use of vehicles", no major opportunities for energy conservation were identified.

13. Potential Effects on Wilderness Resources

a. Alternative 1 - No Action

Since the western spruce budworm is an indigenous component of the forest environment, any effects to the trees during a naturally occurring budworm outbreak are, by policy, an acceptable part of the natural ecology.

b. Alternative 2 - Direct Suppression with B.t.

Some people would be concerned about the use of B.t. within Forest Service Wilderness since application of insecticides could not be considered a naturally occurring event. This would interfere with the natural processes which are a key part of the wilderness resource. Also, the application process would detract from the solitude and primative recreation experience offered in wilderness. However, no treatment in Wilderness is planned in 1988.

14. Potential Effects on Visual Resources

a. Alternative 1 - No Action

During the outbreak, trees in the infested area would take on a brown or gray appearance. This discoloration would lower the aesthetic values of these areas in the perception of some people. When the budworm populations collapse the areas would have a green appearance again in a year or 2, except in those areas which experienced high levels of tree mortality.

b. Alternative 2 - Direct Suppression with B.t.

Treatment of analysis units in 1988 would result in a greening of the trees within treated units in 1989 and, with intermediate treatments as needed, until the outbreak collapses. Discoloration would still be very evident in 1988.

Forest stands which have already experienced a large amount of top-kill and mortality would have a grayish appearance for several years following treatment.

15. Potential Effects on Classified Streams, Watersheds, Floodplains, and Wetlands

a. Alternative 1 - No Action

Under this alternative, there would be no charge from the effects expected due to ongoing forest management operations.

b. Alternative 2 - Direct Suppression with B.t.

There will be no important effects to streams, watersheds, floodplains and wetlands during normal spraying operations. Mitigating measures have been developed and will be implemented to reduce the potential for accidents from either ground or aerial activities which could result in spills in these areas.

Spills would involve a short-term contamination of the areas. A spill plan will be developed and implemented to prevent or reduce contamination.

C. Consequences Common to Both Alternatives

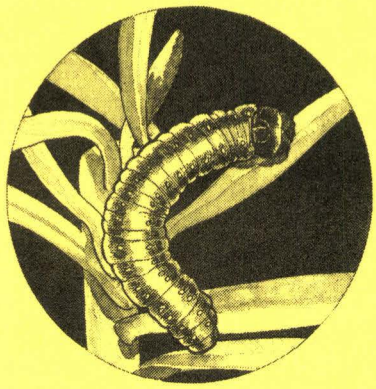
1. Prime Farmland and Rangeland

There will be no known effects on prime farmland or rangeland from the alternatives considered in this analysis.

2. Social Factors

The effects of both alternatives on consumers, civil rights, minority groups, and women are estimated to be minor. Generally, these effects are related to the supply of wood fiber and the resulting cost of wood products. Primary and secondary employment associated with the manufacture of wood products is also a consideration.

The social environment for the analysis area is adequately discussed in the unit land management plans listed in Section I.C.1. of this EA.



V. Consultation

V. CONSULTATION

A. Public Involvement Process

The public's interest in the management of the western spruce budworm situation in Oregon and Washington continues at a high level. The Interdisciplinary (ID) Team which conducted this environmental analysis of the budworm situation used the public involvement process developed in 1986 and 1987 as the basis for the 1988 program. The 1986 process was a structured public involvement program for the analysis that would 1. Keep concerned segments of the public informed about the analysis and subsequent decisions, and 2. Assist the ID team in identifying issues, concerns, and opportunities (ICO's) and in developing alternatives. Since the 1988 Environmental Analysis is an update of those conducted in both 1986 and 1987, it relied heavily on input obtained during those years as well as on input obtained during the present analysis.

Public involvement in budworm analyses began in 1981 in northeastern Oregon where the first defoliation of the current outbreak appeared. Environmental analyses have been conducted for the defoliated area in 1981, 1982, 1983, 1984, 1985, 1986, and 1987. ICO's were gathered for each of those environmental analyses through public meetings, mailings, and personal contacts.

In 1986, an extensive public involvement process was initiated which included gathering background information from documents of other agencies pertaining to budworm management, newspaper clippings, and appeals from past decisions; as well as issues and concerns gathered over the previous years. In addition, mass mailings were conducted, several news releases were made, and a number of public meetings were held. A detailed description of the public involvement process can be found in the 1986 EA Document Western Spruce Budworm Management in Oregon and Washington During 1986 in Chapter V, Section B Public Involvement Process, Pages 78 and 79.

In October 1987, a letter was sent to all the cooperators, outlining the intentions of conducting an analysis for 1988, and requesting their input. In addition, a similar letter was sent to all individuals on the mailing list for the 1987 assessment, requesting additional input and identification of any new issues and concerns. Based on response, it was determined that the seven major issues and concerns described in the 1986 and 1987 EA's were still valid and that no new major issues and concerns had surfaced.

Several meetings were held with interested or concerned parties in both Washington and Oregon in 1985, 1986, and 1987 for additional input.

Throughout the fall of 1987, several news releases have been made regarding the analysis of the western spruce budworm situation, and the possibility of a treatment program in 1988.

Informal consultation with the United States Department of the Interior, Fish and Wildlife Service, has been initiated through telephone contact and written request regarding the status and mitigating measures for threatened and endangered species occurring within the analysis units. The U.S. Fish and Wildlife Service provided lists of threatened or endangered and candidate species. Mitigating measures for no effect on threatened or endangered species were developed for their concurrence (Re. 1-7-88 sp-13 and 1-3-88 sp-33).

Use of Public Input in the Process

The public's response to the above steps contained a broad array of opinions about issues, concerns, opportunities, and alternative actions. Using this information, the ID team identified the seven major issues elaborated in Chapter I and developed the alternatives and mitigation measures described in Chapter II of this EA.

Distribution of the Environmental Assessment

During March 1988, those people and organizations previously contacted will be sent a letter inquiring about their interest in the analysis. Those that request it, can receive a copy of the environmental assessment.

B. Individuals and Organizations Consulted

During the course of the present and past years' analyses, the following individuals and organizations were consulted.

Name	Position	Organization
Susan J. L. Stepniewski	District Wildlife Biologist	Wenatchee NF
Bill Garrigues	District Hydrologist	Wenatchee NF
Steven Kessler	Forest Fisheries Biologist	Wenatchee NF
Terry Luther	Wildlife Biologist	BIA
Richard French	Forester	BIA
Rodney Johnson	Wildlife Biologist	Umatilla NF
Randy Dohrmann	Resource Asst.	Umatilla NF
Rod Miller	Forest Wildlife Biologist	Wallowa-Whitman NF
Dean Longrie	Forest Wildlife Biologist	Mount Hood NF
Richard Gritz	Forest Fish Biologist	Malheur NF
Kirk Wolff	Forest Hydrologist	Malheur NF
Paul Joseph	I & D Forester	Oregon Dept. Forestry
Mark Henjum	Region Nongame Biologist	Oregon Dept. F&WL
Ed Schroeder	Silviculturist	Boise Cascade Corp.
Rick Brathovde	Silviculturist	Boise Cascade Corp.
Bud Fisk	Area Forester	Boise Cascade Corp.
Dan Blatt	Wildlife Area Manager	Wash. Dept. Fisheries
Phil Peterson	Habitat Manager	Wash. Dept. Game
Chuck Chambers	Lead Biometrician	WDNR
Larry Charlton	Ellensburg Local Manager	WDNR
Bernard Murphy	Klickitat Dist. Manager	WDNR
Dianna Hwang	Wildlife Biologist	U.S. Fish & Wildlife
Russell Peterson	Field Supervisor	U.S. Fish & Wildlife

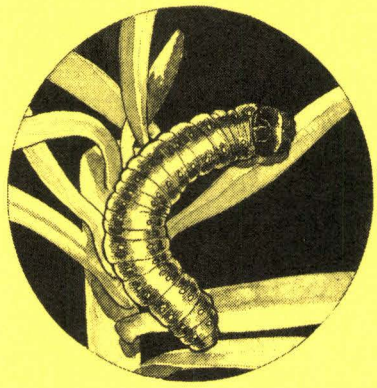
Jim Michaels	:	Wildlife Biologist	:	U.S. Fish & Wildlife
Grant Gunderson	:	Wildlife Biologist	:	USDA Forest Service, RO
Kathy Johnson	:	Wildlife Biologist	:	USDA Forest Service, RO
Ray Quintanar	:	Assistant Fire Staff	:	Colville NF
Frank Lehto	:	Fire Planner	:	USDA Forest Service, RO
Eric LaGasa	:	Entomologist	:	Washington Dept. Ag.
Robert Cooper	:	Research Technician	:	Wenatchee NF
Norm Anderson	:	Forestry Technician	:	Wenatchee NF
Jim Tyler	:	Resourse Assistant	:	Wenatchee NF
Deborah Naslund	:	Data Mgr., Nat. Heritage	:	WDNR

The following individuals and organizations provided valuable input to the 1988 Environmental Analysis

Ronald S. Yockim	Prairie Wood Products	Riddle, Oregon
Jean C. Meddaugh	Oregon Environmental Council	Portland, Oregon
Lou Levy	Cunningham Sheep Company	Pendleton, Oregon
Larry L. Cribbs	Our National Forest, Inc.	La Grande, Oregon
James C. Geisinger	Northwest Forestry Assoc.	Portland, Oregon
Paulette L. Pyle	Oregonians for Food & Shelter	Salem, Oregon
William R. Keyser	City of The Dalles	The Dalles, Oregon
Sandra Saint-John	Private Individual	Portland, Oregon
John J. Howard	Union County Court	La Grande, Oregon
Chet & Mary Schiewe	Private Landowners	Pendleton, Oregon
Wayne Wehling	Washington State University	Pullman, Washington

The following Governmental agencies provided valuable input during the 1988 Environmental Analysis

Stanley D. Butzer	Bureau of Land Management	Portland, Oregon
Anthony R. Morrell	Bonneville Power Administration	Portland, Oregon
Russell D. Peterson	USDI Fish & Wildlife Service	Portland, Oregon
Ronald W. Hasselman	USDI Fish & Wildlife Service	Clackamas, Oregon
Art Stearns	Wash. Dept. of Natural Resources	Olympia, Washington
Richard French	USDI Bureau of Indian Affairs	Portland, Oregon
Tom Haberstroh	USDI Bureau of Indian Affairs	Pendleton, Oregon
Glen Lisle	USDI Bureau of Indian Affairs	Toppenish, Washington
LeRoy Kline	Oregon State Dept. of Forestry	Salem, Oregon
Dave Overhulser	Oregon State Dept. of Forestry	Salem, Oregon



VI. Appendix A
List of Preparers

APPENDIX A

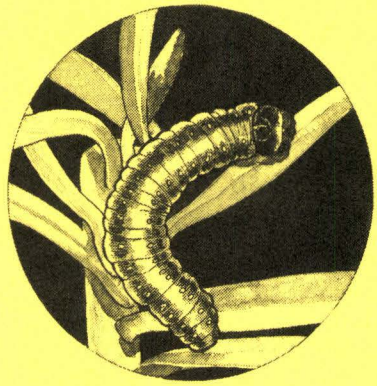
List of Preparers

Interdisciplinary Core Team

Steve Howes	R-6 Forest Pest Management - Team Leader
Roger Sandquist	R-6 Forest Pest Management - Entomologist
Alexis Jackson	Malheur National Forest - Information Officer
Doug Daoust	Mt. Hood National Forest - Silviculturist
Gary Rollins	Umatilla National Forest - Silviculturist
Larry Hansen	USDI, BIA, Warm Springs Reservation - Forester
Rod Johnson	Umatilla National Forest - Wildlife Biologist

Support Team

Marc Wiitala	R-6 State & Private Forestry - Economist
Tommy Gregg	R-6 Forest Pest Management - Biometrician
Sara Zimmer	R-6 Forest Pest Management - Entomologist
Bill McArthur	Malheur National Forest - Silviculturist
Doug Burns	Willamette NF, Lowell RD - Silviculturist
Bob Walkowiak	Mt. Hood NF - Barlow RD - Reforestation Forester
Keith Fagerberg	Mt. Hood NF - Barlow RD - Silviculturist
Ernie Collard	Wallowa-Whitman National Forest - Silviculturist
Jim Trowbridge	Umatilla NF - Walla Walla RD - Forester
Rick Brathovde	Boise Cascade Corp. - Silviculturist
Paul VanCleve	Champion Timberlands - Silviculturist
Paul Joseph	Oregon State Dept. of Forestry - Insect & Disease Forester
Rick Johnsey	Washington Dept. Nat. Res. - Entomologist
Teresa Valentine	USDI, BIA, Yakima Reservation - Forester
Barbara Kennedy	Mt. Hood National Forest - Information Officer
Kent Churchill	R-6 NEPA Coordinator
Gail Saunders	R-6 Media Design Specialist



Appendix B
Pesticide Background Statement
Bacillus thuringiensis

APPENDIX B

PESTICIDE BACKGROUND STATEMENT[1/]
Bacillus thuringiensis

I. SUMMARY

Bacillus thuringiensis (*B.t.*) is a microbial insecticide that is particularly effective in controlling a number of insect species of the order Lepidoptera. *B.t.* is formulated as a suspendable powder which is applied as a water-based aerosol. The active ingredients of *B.t.* preparations are bacterial spores, which infect tissues of sensitive insects, and a crystalline protein toxin, which becomes active only in the gut of insects with alkaline pH and the proper digestive enzymes.

There are limited scientific data available on the environmental fate of *B.t.* in soil and water; however, the studies which have been conducted indicate that the bacterial spores of the *B.t.* formulations tested may persist in the soil for at least several months. In water, viable spores are not expected to persist for more than 1 month. The primary cause of inactivation of the spores in the environment is sunlight, although a number of environmental factors affect the viability of spores; i.e., the susceptibility to solar radiation is enhanced under humid conditions.

In field tests of *B.t.*, no adverse effects on mammals, birds, fish, aquatic invertebrates, or on predaceous or parasitic insects have been observed. Neither mutagenic nor teratogenetic effects have been reported for any of the biologically active components of *B.t.* formulations used to control forest pests. With the exception of two unusual cases involving accidental exposure, *B.t.* has never been reported as causing disease in man or in other vertebrates. Furthermore, no adverse effects of occupational exposure to *B.t.* have been reported for either application workers or production workers.

II. INTRODUCTION

This pesticide background statement was compiled to provide a review of the available information concerning the use, chemistry, toxicology, and environmental fate of *B.t.* in forest applications. The information in this review is intended to supplement the analysis in the environmental assessment. It is not within the scope of this background statement to critically evaluate and/or analyze the raw data from which conclusions were reached in the various studies and reports used in preparing this document.

[1/] Originally compiled in 1984 by Jesus Cota, USDA Forest Service, Southwestern Region, Albequerque, NM. Revised in 1987 by Roger Sandquist, USDA Forest Service, Pacific Northwest Region, Forest Pest Management, Portland, OR. A comprehensive review of *Bacillus thuringiensis* var. *kurstaki*, prepared by the MITRE Corporation, is available for review in the Forest Pest Management office at 319 SW Pine St., Portland, Or 97208.

III. GENERAL INFORMATION

B.t. is a naturally occurring bacterium which is pathogenic to a number of insect species primarily in the order Lepidoptera (moths and butterflies). All bacteria in the genus Bacillus produce, during their life cycle, a dormant form called endospores. Endospores are highly resistant to both heat and desiccation. Therefore, they can persist for long periods when the environment is unfavorable for bacterial growth. The spores in these rod-shaped bacteria are formed several hours after vegetative growth slows and cells enter the stationary phase. The mature spores (endospores) are oval bodies located either centrally or subterminally within the parent cell, the sporangium. A distinctive feature of B.t. is the presence of a bipyramidal crystal, the parasporal body, within the sporangium. This crystal, which has been called "delta-endotoxin", can be seen under the microscope. It appears as a tiny, diamond-shaped crystal inside the cell (Figure 1). The crystalline endotoxin is the principal active ingredient of B.t. insecticidal formulations, while the spores constitute the second active ingredient.

B.t. was first isolated in Japan in 1901 from diseased larvae of the silkworm (Bombyx mori Linnaneus) and re-isolated in 1911 from diseased larvae of the Mediterranean flour moth (Anagasta kuehniella (Zeller)). The first commercial use in the United States occurred in 1958 when application of the B.t. formulation, Thuricide, directly to food and forage crops under the conditions of a temporary exemption from a tolerance was authorized. Since that time, B.t. use has expanded to include forest insect pests. The first aerial applications of B.t. against the spruce budworm (Choristoneura fumiferana Clem.) were in New Brunswick in 1960. The cumulative total acreage aerially sprayed in the United States between 1958 and 1974 for suppression of forest insect populations was 23,000 acres. In recent years, B.t.'s major use in forestry has been for spruce budworm control, mostly in the State of Maine. B.t. was applied to about 200,000 acres during the 1980 spray program in Maine; in 1983, B.t. was applied to 53,649 acres (780,304 BIU's) for control of the western spruce budworm (C. occidentalis Freeman) in the western United States.

Since 1983, about 150,600 acres of forested land in Oregon and Washington have been aerially sprayed with B.t. for control of western spruce budworm. In the last few years, several tests have been conducted by the USDA Forest Service to obtain performance data on B.t. against western spruce budworm. Results of all field and pilot tests are summarized in Table 1.

Independent isolations of B.t. have produced a number of varieties and strains of this bacterium that differ in their pathogenic properties as well as in their serological reactions. Early formulations of B.t. manufactured in the United States were produced from B. thuringiensis var. thuringiensis and contained a second toxin called "beta-exotoxin" which has a broad range of toxicity to insects including honeybees.

However, damage to bees occurs only at application rates much higher than the recommended rates. All B.t. formulations currently manufactured for control of forest insect pests are produced from the variety kurstaki strain (HD-1). This strain was selected for its high virulence to target Lepidoptera. It is nontoxic to honeybees because it does not produce the beta-exotoxin.

In the United States, the quality of B.t. formulations is regulated. The biological activity of the complex "spores-crystalline endotoxin" is expressed in activity units, for a specific insect test species, and related to an international standard preparation. The B.t. preparation E-61 of the Pasteur Institute in Paris has been chosen as primary standard, and is assigned a specific activity of 1,000 international units per milligram (IU/mg). Insect potency of B.t. formulations, therefore, is determined by a bioassay, which is based on the well-established international unit system. All preparations of B.t. sold in the United States are required to list the number of international units on their labels.

There are two major manufacturers of B.t. in the United States, as well as several smaller ones. The principal market for use is in the agricultural crops, particularly vegetables, cotton, tobacco, and soybeans, with minor use in forestry. A number of B.t. products are available for use against the western spruce budworm; these are sold under the registered trade names: Dipel, Thuricide and Bactospeine.

A. Physical and Chemical Properties

The pathogenic bacteria of insects are generally classified as either sporeformers or nonsporeformers; B.t. belongs to a genus of rod-shaped, gram-positive, sporeforming bacteria that grow aerobically or facultatively anaerobically. Its vegetative cells are approximately 1 um in width and 5 um in length. The cells are motile and are propelled by a peritrichous flagellum. Many isolates of B.t. have been reported and are grouped into bacterial varieties. The 19 varieties of B.t. known have been serologically separated into 14 serotypes, each having a different spectrum of activity. Thirteen of the serotypes are active against more than 182 species of insects, in particular against pest species of the order Lepidoptera. The remaining serotype, B. thuringiensis var. israelensis, is highly toxic to certain Diptera; notably, mosquitoes and blackflies. The varieties of B.t. are distinguished from other bacilli by their capacity to form distinctive crystals within the cell. The commercial variety, kurstaki, can be further separated into two types, K-1 and K-73, by the selective antigenicity of the crystal.

Currently in the United States, commercial formulations registered for forest pest control contain the HD-1 strain of Bacillus thuringiensis var. kurstaki which is a serotype III variety. This strain was discovered in the late 1960's by Howard Dulmage who found it to be 10 to 100 times more potent than the strains being produced at the time.

Preparations of B.t have been tested against insect species from the orders Lepidoptera, Hymenoptera, Diptera, and Coleoptera. The most susceptible group of insects are those in the order Lepidoptera having alkaline gut contents (pH 9.0 - 10.5) and digestive enzymes to dissolve the crystals and activate the toxin.

The two main insecticidal toxins synthesized by B.t. varieties are the proteinaceous endotoxin widely used in the control of Lepidoptera pests and the exotoxin, a nucleotide produced by varieties no longer used in insecticidal formulations. The latter toxin is not produced by the kurstaki variety of B.t.; however, the thuringiensis variety does produce the exotoxin. The exotoxin is structurally related to adenosine triphosphate (ATP), and inhibits RNA and DNA in vitro. In addition, exotoxin is a competitive inhibitor of adenylcyclase, and, at high concentrations, it inhibits cellular protein synthesis. Exotoxin is able to cross cell and nuclear membranes and is toxic for mammals by injection. B.t. strains capable of producing the heat-stable exotoxin have been experimentally used in the control of several pest insects, especially flies. Use of such strains is no longer recommended.

B. Mode of Action

B.t. must be ingested by susceptible insects before it can kill. This normally occurs when larvae feed on foliage sprayed with B.t., thereby ingesting both endospores and crystalline endotoxin. The crystal is comprised of a protein that is insoluble at acidic or neutral pH, but is soluble at alkaline pH. Those insects that have alkaline gut contents between pH 9.0 and 10.5 are capable of solubilizing the B.t. protein crystal. The solubilized (dissolved) protein must be cleaved by digestive enzymes to form the active toxin which works by attacking the gut lining of epithelial cells. This allows molecules in the alkaline gut to diffuse into the hemolymph (blood cavity), increasing the pH of tissues and resulting in paralysis. When the epithelial gut lining has been sufficiently damaged, ingested spores can pass into the hemolymph and germinate. Here, the bacteria multiply rapidly, destroy certain tissues, and soon fill much of the insect cavity. This bacterial growth stage of the infection is termed "septicemia". The general pathological symptoms shown by lepidopteran larvae when fed B.t. are rapid gut paralysis, sluggish behavior, cessation of feeding, and finally death. Histological (tissue) studies have indicated that the delta-endotoxin causes gross disruption of the midgut epithelium; cells balloon and lyse with severe disruption of the gut wall. Histopathological evidence indicates that the gut epithelium is the primary target area and that the endotoxin is the principal active component in B.t.

In highly susceptible insects, only the toxin is needed for control, but, in less susceptible insects, the synergistic effect of spores together with the endotoxin is required. Since the chitinous layer in the insect gut is the main barrier that B.t. must pass through in order to invade tissues, some investigators have added chitinase, an enzyme that hydrolyzes chitin, to B.t. formulations. This approach appears to increase the virulence of B.t. preparations in laboratory tests, but, despite various field tests, addition of chitinase has not been universally accepted as beneficial for field use.

IV. TOXICITY

A. Invertebrates

Nontarget invertebrates are not expected to be harmed by exposure to B.t. at levels commonly encountered after spraying for forest pests. In field tests in Nova Scotia, where B.t. was the only insecticide applied to an apple orchard over a 4-year period, population levels of lepidopteran insects were reduced, but there was no effect on predaceous insects (Jaques 1965).

Spruce-fir stands in Algonquin Park, Ontario (Canada), and mixed forest containing mature spruce stands, poplar bluffs, and areas of dense brush and open fields in Spruce Woods, Manitoba, were sprayed with formulations of Thuricide 16B or Dipel WP. Although some declines in populations of nontarget insects were observed, comparison with the controls indicated that the declines could not be attributed to the spraying (Buckner et al. 1974). In these studies, there was also no significant increase in mortality among foraging bees as a result of B.t. treatment. Many other studies have been made on the effects of B.t. on honeybees. These studies have found no evidence that bees will be harmed by B.t. at the levels commonly used in forest spray operations. B.t. has been shown to be nontoxic to bees at levels as high as 726,000 spores per bee.

Few toxic effects have been reported in studies of B.t. exposure to aquatic species. While monitoring aquatic species on Moresby Island, British Columbia in 1960, Todd and Jackson found no adverse effects on aquatic insects in streams within an experimental area treated with B.t. In studies in Algonquin Park, Ontario, Canada, fish and bottom fauna suffered no adverse effects up to 4 weeks after spraying (Buckner et al., 1984).

It is well known that, besides insects, a large number of other invertebrates play an important role in most ecosystems; one important group of reducing organisms are the earthworms. One study has shown B.t. to be fatal to earthworms only at concentrations 104 to 105 times higher than that which would occur in the soil after normal application in the field. However, these studies were carried out using B. thuringiensis var. thuringiensis that produces beta-exotoxin which could have influenced the results. In experiments using Dipel (16,000 IU/mg) at dose rates of 60, 600, and 6,000 mg/m2 on forest plots and Bactospeine (1000 IU) at a dose rate of 30 gm/m3, worm density after spraying was not significantly different from worm density prior to spraying. Both of these formulations contain B. thuringiensis var. kurstaki (Berry and Altwegg, 1975).

B. Mammals and Birds

Field tests have not revealed any deleterious effects of B.t. on populations of birds and mammals. In studies in Algonquin Park and Spruce Woods, no significant differences were found between populations of birds and mammals on the sprayed plots compared to populations of the same species on the untreated plots. In a second test, aerial application of Dipel WP applied at a rate of 0.5 pounds per acre to a Scotch pine plantation containing a large population of nesting morning doves apparently did not affect or disturb the birds. Twenty-four hours after spraying, fledglings were observed still in their nests and adults were flying about the plantation. After 28 days, adults were still numerous.

In a test by Briggs and Goodrich (1959), 17 pheasants and two partridges were used to determine the oral toxicity of B.t. to game birds. The test group was fed 1.0 gm of B.t. per bird per day in two gelatin capsules, while the control group received only gelatin capsules. No deaths or symptoms of respiratory, alimentary, or other disturbances were noted in the test group. In the control group, two pheasants died of trauma due to handling. Birds in both groups exhibited similar feather color and pattern, bearing, and weight gain as expected for birds in nature. The conclusion made by the researchers was that no significant difference in behavior or development occurred between the test and control group of birds. In the same study, six New Hampshire Red laying hens were fed daily doses of B.t. ranging from 0.5 to 10 gms per bird for more than 23 months. Results indicated no variation in egg production, no allergic response to the B.t., and no disease in test birds. Fisher and Rosner (1959) conducted an oral toxicity test with chicks and found that there were no significant deleterious effects after administering B.t. to test birds for 9 weeks.

Game birds have also been used in detailed studies to determine the effects of acute oral dosages of B.t. on body tissues. In a study (IBT 1970) using adult bobwhite quail, five male and five female quail were fed 10 gm/kg of B.t. by introducing the preparations into the stomach with a tube (gavage), while control animals were fed distilled water. At the end of a 21-day period, all animals were sacrificed and subjected to tissue examination. Gross pathological examinations indicated no abnormal tissue differences attributable to B.t. between test groups. In addition, growth rates were also similar in the test and control groups.

Extensive laboratory tests have produced no evidence that B.t. is pathogenic to vertebrates which inhale, ingest, or come into contact with it. Table 3 summarizes the results of some of these studies. Rats were given a single oral dose up to 24 gm/kg of body weight without adverse effects. When mice were injected with large numbers of B.t. spores and cells (106-109), some individuals died. This appeared to be the result of toxic substances in the B.t. preparations, since death also occurred after injecting heat-killed preparations. No evidence of infection was seen, and bacteria completely disappeared from the blood by 72 hours after injection.

B.t. administered by mouth as the spore-crystal complex to rats daily for 3 months at rates of 25, 100, and 400 mg/kg produced no main function disorders or organ damage. Similar results were obtained in dogs fed 6, 25, and 100 mg/kg for 3 months (Fisher and Rosner 1959, Corlett 1961).

Fed to groups of 10 mice (16 to 25 gms.) at the rate of 10 gm/kg B.t., (Dipel) caused no mortality with the LD50 being greater than 10 gm/kg (IBT 1970a). B.t. (Dipel) was fed to three female mongrel dogs at a dosage of 400 mg/kg. The animals were free of any symptoms during the 48-hour observation period (IBT 1970a).

Eighteen human volunteers inhaled 100 mg/day of Thuricide powder and each ingested 1 gm/day for 5 days. Complete physical and laboratory examinations were given before the experiment, at the end of the 5-day ingestion period, and 4 to 5 weeks later. Physical examinations included detailed history and records of height, weight, temperature, blood pressure, respiratory rate, and pulse rate immediately after exercise and 30 to 60 seconds thereafter. Evaluations were made of genitourinary (reproductive and urinary system), gastrointestinal, cardiorespiratory, and nervous systems. Laboratory tests included routine urinalysis with qualitative and quantitative urobilinogen determinations (when indicated), complete blood count, sedimentation rate, blood urea nitrogen, glucose, bilirubin, and thymel turbidity tests. All subjects remained well during the course of the experiment. All laboratory findings were negative (Fisher and Rosner 1959).

In a study by Thomas and Ellar (1983), the effects of purified crystalline endotoxin of B. thuringiensis var. kurstaki were observed on insect and mammalian cells in vitro and in vivo. Mouse fibroblasts, primary pig lymphocytes, and three mouse epithelial cell types were exposed to the endotoxin and showed no detectable cytological or cytopathological changes. Similarly, rat, mouse, sheep, horse, and human erythrocytes exposed to the delta-endotoxin indicated no hemolytic activity. In a laboratory strain of mice, the Balb. C. strain, intravenous, subcutaneous, or per os (by mouth), administration of high dosage rates (15 to 30 ug of protein per gram body weight) of the alkali-soluble crystal delta-endotoxin did not have any toxic effects on the experimental animals.

C. Fish

Data from in vivo tests evaluating the safety of B.t. to fish (Table 3) show B.t. to be either nontoxic or toxic only at very high doses. A 4-day toxicity study was conducted with B.t. on rainbow trout and bluegills. Two groups of ten fish each were placed in water containing B.t. at concentrations of 560 and 1,000 parts per million (ppm). None of the trout or bluegills died (Fisher and Rosner 1959). Rainbow trout that were 4 inches long were exposed to B.t. at concentrations of 100 to 1,000 ppm for 14 days. No deaths resulted, nor were there symptoms of alimentary or behavioral disturbances evident (Fisher and Rosner 1959).

In a test with juvenile coho salmon (1.6 inches long), B.t. was about 1/30 as toxic as DDT. The tests ran for 168 hours, with concentrations of eight to 406 mg B.t. per liter of water. The 48-hour median tolerance limit of the B.t. was about 50 mg/liter (Fisher and Rosner 1959).

D. Other Toxic Effects

Neither mutagenic nor teratogenic effects for mammalian systems have been reported for any of the biologically active components of the B. thurigensis var. kurstaki formulations used to control forest pests.

In an extensive long-term feeding study undertaken in Finland, the mutagenicity of B.t. preparations was tested in different mammalian systems. Human blood cultures treated with toxic concentrations of the supernatant of serotype III showed no significant increase in the incidence of chromosomal aberrations or mitotic arrest. In acute exposure and long-term feeding studies with rats, no effect was observed on the incidence of chromosomal breakages in the bone marrow cells. The results of these experiments lead the researchers to conclude that when used in proper concentrations for the control of pest insects, preparations of B.t. most probably do not cause cytogenetic damage to other living organisms.

B.t. has been reported to be a human pathogen in only one case in which it was identified as the causal agent for a corneal ulcer (Sumples and Buettner 1983). This case involved a healthy 18-year-old farmer who accidentally splashed a suspension containing B.t. in his right eye and developed an ulcer 10 days after treatment with a corticosteroid ointment. Although a bacillus resembling B.t. was identified in cultures taken from the corneal ulcer, medical opinion seems to question the involvement of B.t. (Dr. J. B. Curry, personal communication). The lack of reports linking B.t. to eye infections, along with safety data collected in tests with laboratory animals, seems to substantiate this medical view. For example, Fisher and Rosner (1959) tested albino rabbits for ocular irritation by B.t. A dosage of 0.1 cc of a 20-percent suspension was instilled in each eye of test animals. One eye was rinsed immediately with isotonic saline, while the other was left alone. Eyes were examined immediately after application, 3 and 24 hours after application and thereafter every 24 hours, until they appeared normal. Slight redness of the eyelids was noted at 3 and 24 hours after application; however, eye irritation disappeared in 48 hours.

Allergenicity of B.t. to guinea pigs and rabbits has been tested in two studies (Fisher and Rosner 1959; Corlett 1961). In both studies, dermal application of B.t. suspensions was made. In the guinea pig study, sensitizing doses were administered by intracutaneous injection and by the abrasion-patch technique, while in the second study,opical application to the shaved flanks and bellies of rabbits was made. A slight redness of the skin was noticeable in the injected and abraded animals, indicating local irritation. Topical applications had no effect.

As a result of the widespread natural occurrence of B.t., there is certainly occasional human exposure to this organism through inhalation, ingestion, and wound contamination; however, based on the information on the studies reviewed, it is highly unlikely that the registered use of B.t. would pose a human health hazard. Furthermore, no adverse effects of occupational exposure to B.t. have been reported for either application workers or production workers after more than 24 years that B.t. formulations have been used in programs to control pest insects.

V. ENVIRONMENTAL FATE

Most studies on the persistence of B.t. in the environment have been directed at following viability of B.t. spores rather than following endotoxin activity. This is primarily because the presence of the crystal in nature is much more difficult to detect than is the presence of spores. Those studies that have been carried out to follow persistence of the crystalline endotoxin show that it disappears from the environment at a steady rate, although somewhat slower than the disappearance of B.t. spores.

Studies on the fate of B.t. in the environment indicate that B.t. spores will persist in soil for several weeks, depending on the soil type, soil flora, and on factors such as pH, moisture, and solar radiation. A study of soils treated with B.t. applied for vegetable pest control concluded that spores can remain viable for long periods (over 3 months), and that the organism can germinate and compete vegetatively in the soil and sporulate successfully under favorable soil conditions (Salek 1969). The crystal endotoxin is proteinaceous in nature; therefore, degradation by the enzymatic action of soil flora can be presumed.

Survival of B.t. on leaves is minimal when no additives are included in sprays (IMC 1969). New formulations designed to protect B.t. from the ravages of environmental forces have shown considerable biological activity after 21 days of field exposure, and negligible biological activity after 1 month.

B.t. spores and vegetative cells occur naturally in a number of environments not contaminated by B.t. insecticide formulations. This organism is commonly found where susceptible insects inhabit the environment. For example, it is frequently found in stored grain and in the soils of environments with high concentrations of lepidopterous larvae.

When B.t. is applied in nature, the spores rapidly disappear. The primary cause of inactivation of B.t. spores in the environment is probably sunlight, although spores are generally resistant to heat, shortwave radiation, and toxic chemicals. It has been shown that moist, unprotected spores of B.t. are rapidly killed by exposure to sunlight. Further studies also suggest that spores exposed to sunlight are less susceptible to solar radiation damage under very dry conditions. When four commercial B.t. preparations were sprayed on coast live oak at

different locations, the viable spores persisted longer in the hot, dry climate than in the cool, moist climate. In another study, the persistence of four B.t. formulations was tested on redbud tree leaves at two sites in California: Auburn (altitude, 374 m) and Sacramento (altitude, 10 m). The rate of decay of viable spores was not significantly different, although the amount of solar radiation was greater at Auburn. It was concluded that since the relative humidity at Auburn was lower (21.7 percent vs. 27.5 percent), the drier conditions may have compensated for any differences in solar radiation levels.

Sunlight and humidity are probably not the only factors affecting the persistence of spores on vegetation. It has been suggested that the initial B.t. deposit retained on the leaves after application and the subsequent decay or loss of viable spores may be determined to some extent by the leaf type or species, based on studies measuring viable spore decay on the leaves of four different species of trees (California live oak, redbud, eucalyptus, and walnut) subject to the same climatic conditions.

It is generally recognized that endospores can remain dormant for a long period of time; in some cases for many years. B.t. has been known to remain active in soil for at least 4 months. In laboratory studies evaluating some of the factors affecting the survival and competitive growth of B.t. in soil, Saleh et al. (1970) confirmed that spores of B.t. can remain viable for long periods of time in soil when germination-inducing stimuli are absent. Under conditions favorable for the growth of soil bacilli, such as neutral pH and presence of proteinaceous matter, B.t. can germinate and compete in the vegetative phase with other soil micro-organisms. B.t. can also sporulate successfully to levels of more than one million spores/gm soil. Microbial degradation of the crystalline endotoxin is possible at moderate temperatures. Molds which produce extracellular proteases (enzymes) capable of digesting the endotoxin grow at temperatures as low as ten degrees C.

Although few studies are available on the fate of B.t. in water, one study suggests that B.t. will not persist in aquatic systems, based on data collected from monitoring river water following aerial applications of Thuricide to forest plots in Canada. The viable spores present in river water and clams immediately after treatment disappeared within 4 weeks.

Since B.t. is exempted from tolerance, no residue analysis on food or feed has been performed when B.t. has been used for forest insect control (Heimpel 1971).

TABLE 1.--Summary of B.t. studies conducted against western spruce budworm Choristoneura occidentalis

Formultation	Dose/rate	Mortality % unadjusted/ (day evaluated)
1975 (Thompson et al. 1977)		
Dipel WP + 0.125% BioFilm	8 BIU/2 gal/acre	13 (14)
Dipel WP + 25% Molasses	8 BIU/2 gal/acre	31 (14)
Dipel WP + 25% Sorbo	8 BIU/2 gal/acre	28 (14)
Dipel WP + Sorbo + Shade	8 BIU/2 gal/acre	61 (14)
Dipel WP + Sorbo + Sticker	8 BIU/2 gal/acre	37 (14)
Thuricide 16B	8 BIU/gal/acre	45 (14)
Thuricide 16B	8 BIU/gal/acre	45 (14)
Thuricide 24B	8 BIU/0.5 gal/acre	56 (14)
Thuricide 32B + Sorbo	8 BIU/2 gal/acre	61 (14)
1975 (McGregor et al. 1976)		
Dipel WD + 0.15% BioFilm	8 BIU/2 gal/acre	67 (21)
1978 (Hodgkinson et al. 1979)		
Thuricide 16B	8 BIU/gal/acre	67 (15)
1979 (Stelzer and Scott 1981)		
Thuricide 16B	8 BIU/gal/acre	90 (26)
Thuricide 32B + 25% Molasses	8 BIU/gal/acre	90 (26)
Dipel 4L	8 BIU/gal/acre	87 (26)
1981 (Stipe et al. 1983 and Ragenovich 1983)		
Thuricide 16B (R1)	8 BIU/gal/acre	62 (21)
Thuricide 16B (R3)	8 BIU/gal/acre	88 (21)
Dipel 4L (R1)	8 BIU/gal/acre	48 (21)
Dipel 4L (R3)	8 BIU/gal/acre	79 (21)
1984 (Beckwith, Stelzer, and Hostetler 1984)		
Thuricide 32 LV	8 BIU/96oz/acre	80.3 (16) Douglas-fir
		93.2 (16) Grand fir
	12 BIU/96oz/acre	91.0 (16) Douglas-fir
		96.9 (16) Grand fir
SAN-415	8 BIU/96oz/acre	83.4 (16) Douglas-fir
		88.0 (16) Grand fir
	12 BIU/96oz/acre	94.6 (16) Douglas-fir
		98.4 (16) Grand fir

TABLE 1.--Summary of B.t. studies conducted against western spruce budworm Choristoneura occidentalis (cont.)

1985 Ragenovich unpublished

Dipel 8L	12 BIU/24oz/acre	88.9 (14)
Thuricide 48 LV	12 BIU/32oz/acre	88.7 (14)
Dipel 8L	12 BIU/48oz/acre	91.2 (14)
Thuricide 32 LV	12 BIU/96oz/acre	93.8 (14)

TABLE 2.--Summary of in vivo tests conducted to evaluate safety of Bacillus thuringiensis preparations to fishes, birds, and mammals

Species	Numbers of animals	Inoculum* (billion/kg)	route**	Results
Fishes				
Rainbow trout, black bullhead, yellow perch, mosquito fish	40	<0.01-4.5	TE	Negative
Coho salmon juvenile	20	300-1800	TE	Toxicity at higher doses
Birds				
Wild pheasant	9	3600	diet	Negative
Partridge	2	5800	diet	Negative
Cornish chick	190	0.2	diet	Negative
Chick	48	300-1900	diet	Negative
New Hampshire laying hen	16	1000-3000	diet	Negative
Cockeral, Vantress cross	60	480-15,800	diet	Negative
Mammals				
Mouse	48	0.1-0.3 cells	ip	Lethal dose, 50%
	48	0.04-2 cells	sc	Lethal dose, 50%
	48	0.8-7.8 spores	ip	Lethal dose, 50%
	48	20-160 spores	sc	Lethal dose, 50%
	10	77	po	Negative
	10	15	ip	Abdominal irritation; some death
	10	20,000	ih	Negative
Rat	10	2000	po	Negative
	100	7700	diet	Negative
	20	0.01-1.0	ip	Negative
Guinea pig	10	77	diet	Negative
	10	40	ip	Negative
	10	4000	ip	Negative
	10	0.3	sc	Localized reation at injection site
	10	16	DA	Slight erythema on abraded skin
Swine, duroc	3	185	diet	Negative
Human	18	0.2	po	Begative
	5	0.02	ih	Negative

*Viable spore count of whole culture preparation that included spores, vegetative cells, crystals, and wholeculture broth, unless otherwise specified. estimated body weight was used when active body weight was not provided.
**po = per os; ip = intraperitoneal; ih = inhalation; sc = subcutaneous, TE = topical exposure; DA = dermal application.

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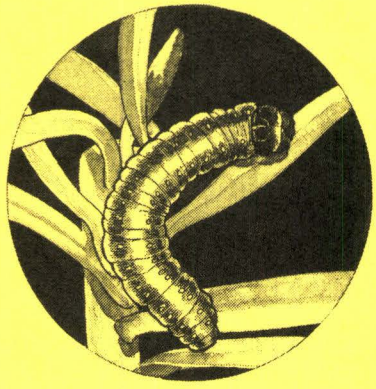

Appendix C
Western Spruce Budworm Economic Efficiency Analysis for Oregon and Washington, 1987

APPENDIX C

ECONOMIC ANALYSIS OF COMMERCIAL TIMBER IMPACTS IN THE PACIFIC NORTHWEST REGION, 1987

This appendix describes the methods and presents results of an economic analysis of budworm effects. The objective is to provide land administrators with information to help judge the relative economic merit of alternative forest protection measures set forth by this environmental analysis. Commercial timber production is the primary focus of attention.

ECONOMIC EFFICIENCY ANALYSIS

The purpose of the economic efficiency analysis is to estimate the economic returns associated with alternative forest resource protection strategies proposed for the current western spruce budworm infestation in Oregon and Washington. The efficiency analysis is conducted only for those costs and benefits that can be reasonably expressed in quantitative terms. The evaluation will produce criteria to: (1) judge the economic merit of alternative management strategies for each analysis unit; (2) establish the most efficient level of funding; and (3), if treatment funds are insufficient to exhaust all economically viable investment prospects, provide a basis for selecting the best prospects.

The economic analysis is conducted in accordance with procedures outlined under Title 3400-FOREST PEST MANAGEMENT of the Forest Service Manual. According to this method the no action alternative is selected as the baseline against which all other alternatives are compared. Each action alternative affords some measure of protection against forest resource output losses or other undesirable impacts effected by a western sprue budworm outbreak. The value (as expressed in 1987 dollars) of resource losses averted minus the value of any adverse resource consequences constitutes the benefits of investing in a pest management alternative. Costs are measured by the value of resources expended in carrying out a management alternative. Once measured for a particular protection investment prospect, benefits are weighed against costs to evaluate its economic viability either on its own account, or relative to competing protection alternatives.

Some forest resources are not exchanged in formal markets and, therefore, have no established market value. If these resources are impacted by the current infestation, other valuation processes will be employed. Among these will be qualitative assessments of value in relation to land management objectives.

Economic Efficiency Measures

The cost-benefit analysis provides two measures for comparing the economic efficiency of the forest protection project alternatives: present net value and benefit-cost ratio. These efficiency measures are prescribed by

Section 3422 of the Forest Service Manual. Present net value (PNV) represents the difference between discounted project benefits and costs. The benefit-cost ratio (B/C) is defined as the ratio of present value of benefits to present value of costs. Present value of either benefits or costs is determined by discounting all future values according to the prescribed discount rate(s).

Discount Rates

Present value of either benefits or costs is determined by discounting all future values according to the prescribed discount rate(s). The discount rates used in this evaluation are consistent with those used in long-term forest planning as outlined under Title 1971 of the Forest Service Manual. The primary rate is 4 percent. To test the sensitivity of the results to higher discount rates, a value of 7 1/8 and 10 percent is used.

Resource Benefit

Budworm management alternatives are evaluated relative to the no action alternative. Management alternatives have the potential to produce both positive and negative resource benefits. Costs arise from project expenditures on budworm control activities and on measures taken to mitigate any adverse resource impacts which might occur during the course of a control project.

A variety of forest resources may be impacted by a budworm outbreak and the alternatives taken to mitigate its impact. These range from fiber production, wildlife habitat, and fisheries to the visual condition of the forest. This general economic analysis limits its consideration to those resources that are identified by the Interdisciplinary Team to be major and common considerations across all land managers and the public. Localized issues and impacts will be addressed separately.

The major quantifiable resource benefit under the treatment alternatives considered is the gain to wood fiber production resulting from measures taken to mitigate budworm activity. As explained in Appendix E, both a stand growth and budworm damage model were combined to project fiber production both with and without budworm impacts for a range of resource conditions and management prescriptions. The difference in volume and timing of fiber production under these two growth scenarios provides the basis for determining fiber production benefits. This appendix outlines the data and methods employed in determining fiber production benefits of a treatment alternative.

Treatment Costs

The major cost item in the cost-benefit analysis is that associated with application of biological insecticides. For some analysis units two applications may be necessary to achieve projected levels of benefits.

Whether a second application is necessary for a particular analysis unit will depend on the level of sustained effectiveness achieved by the first application and the number of years remaining in the infestation. Therefore, per acre protection cost may exceed the cost of an single treatment for newly infested areas.

Many other factors may influence the final per acre cost of treatment. These include items such as contract specifications, market conditions, method of insecticide application. For purposes of testing the sensitivity of the economic results to variations in the cost of treatment, three cost scenarios are analyzed. Based on cost data from the 1987 budworm project, the following per acre treatment cost scenarios are considered:

Cost Scenario	Cost
Low	$16.50
Expected	$19.00
High	$21.50

Decision-making Under Uncertainty

A degree of uncertainty surrounds many aspects of the decision environment covered by this environmental analysis. Type, magnitude, timing, and quality of budworm caused physical resource impacts can only be approximated. Insufficient data exists to make accurate point estimates. Critical economic data necessary for valuing resource impacts, such as current and future stumpage prices, are continually undergoing revision. This uncertainty extends as well to the level of success achievable by the proposed forest resource protection measures.

This environmental analysis takes a step toward providing the land administrator with information regarding the economic implications of major uncertainties. This is accomplished by evaluating the economic efficiency measures over a range of values on the uncertain variables. Through this process it is possible to explore the degree to which the action selected on the basis of the decision criteria (e.g., a B/C equal to 1) is sensitive to variations in the uncertain variables. If the decision is not sensitive to plausible variations, the decision-maker can feel comfortable that a correct decision has been made.

If the decision tends to change with only minor variations in the uncertain variable, the decision-maker should be less certain that a correct choice can be made. In this latter situation, the land administrator may wish to weigh more heavily other criteria in making his decision.

Analysis Unit and Stand Evaluation

The analysis unit (AU) delineates an area based on land management and entomological considerations about which a decision is intended to be made in regard to the forest protection alternatives. The uniqueness of individual analysis units requires that each be evaluated with regard to specific resource characteristics. For this reason resource impacts are identified and evaluated by AU. The specific procedures for estimating fiber impacts are discussed in Appendix E.

Economic evaluation of timber impacts is based on average stand components. This procedure conforms to Section 3422 of the Forest Service Manual. The particular application of stand analysis utilized here allows for economic sensitivity to differences in stand composition. For each pest management alternative, an evaluation of economic benefits and cost is made for the several average stand categories. These categories express differences in stand structure, management intensity, age structure, host composition, species group, land manager, management philosophy, harvest scheduling and local stumpage price variations.

Total AU benefits are determined by aggregating the benefits of treatment for all stands within an analysis unit. Total AU benefits for each forest protection alternative are then compared to the cost protection to determine two measure of economic efficiency: present net value and benefit-cost ratio.

Major Assumptions

Selection of base data, impacts to be included in the analysis, valuation procedures, and other facets of the economic evaluation requires making several assumptions. Assumptions are simplifications of the extremely complex forest management and environmental setting of the budworm infestation and are necessary to carry out this analysis.

No attempt is made to exhaust all assumptions underlying the evaluation. Many are implicit in the analysis. An attempt has been made to document major assumptions made to address specific problems presented by the analysis. While most appear in this section, others are stated in the treatment of related topics.

The following assumptions are based on input from land managers and entomologists. They are a necessary basis for performing the economic evaluation:

1. Entomological units reflect area delineations which afford substantial natural checks to pest immigration. Analysis units which depart from the entomological unit concept will introduce a higher risk to reinvasion.

2. Suppression efforts will be effective in reducing budworm populations to endemic levels. However, there is a risk of resurgence within the time period of the current regional infestation.

3. The timing and damages of subsequent regional budworm outbreaks will be unaffected by the forest protection alternatives selected for 1987.

4. Preliminary fiber impact estimates indicate that their magnitude will not be sufficient to influence forest management activity schedules. Therefore, the timing of volume impacts are assumed to be determined according to existing harvest schedules.

5. Opportunties for salvaging budworm induced tree mortality are expected to be to be limited.

Stumpage Prices and Projections

Future stumpage prices can significantly influence the value of fiber impacts. Because most timber impacts are not expected to be realized immediately, a need exists to project stumpage prices to the appropriate points in time. These projections are made from a baseline. Because of variations between locations and ownerships, baseline stumpage prices per thousand board feet (MBF) for eleven major species are computed for each land ownership area within the scope of the current infestation. Stumpage prices also are scaled to reflected relative differences in value associated with tree diameter.

National Forest stumpage prices are based on a 5-year constant dollar average for the time period currently considered within their respective planning processes[1/]. On private ownerships and other public lands they are based on 5-year county data. For Oregon, these estimates were made by the Oregon State Department of Forestry from data made available by the Oregon State Department of Revenue. Estimates for Washington were provided by the Washington Department of Natural Resources and Boise Cascade Corporation[2/].

Historically, the value of stumpage in the Pacific Northwest has increased over the long term at a rate faster than increases in the general price level. Estimates of historical real annual stumpage price increases range from close to zero to the teens depending on species, time period, location, and estimation methodology. For the future it is unlikely that a rate of real stumpage price increase can be forecast with certainty. For a particular individual, some rates will seem more likely to occur than others. Between individuals there will probably be greater agreement on what the future will not hold than there will be on the likelihood of those possibilities the future could hold.

1/ Revised Chapter VI of the November 10, Regional Direction Package.

2/ Stumpage price data is not displayed in this appendix, but will be made available upon request by the offices of Forest Pest Management, Pacific Northwest Region, Portland, Oregon.

All this uncertainty makes the task of conducting the economic analysis and providing decision-makers with meaningful information quite difficult. The approach taken here is not to attempt to settle upon a specific scenario for future stumpage price increases before conducting the analysis. Instead, economic results for four price increase scenarios are presented. These are judged to span with considerable certainty the most likely range of outcomes over the long term.

BENEFIT-COST RESULTS

A tabular summary of results of the biological impact and economic efficiency evaluation is presented in this section for the Pacific Northwest Region[3/]. The major focus of attention in the economic analysis is fiber production. The information is displayed in several tables and figures reflecting variations in: 1) the costs for each of the three treatment alternatives; 2) the real stumpage price growth assumptions; and 3) the rates of discount. Treatment costs of $16.50, $19.00, and $21.50 correspond to a low cost scenario, a cost per acre based data from the 1987 budworm suppression project, and a high cost scenario, respectively.

In each table, land managers contained within an analysis unit are listed by code under the "Land Manager" column. Major land manager groups are assigned the following codes:

S - Washington or Oregon State, private, county, and/or Bureau of Land Management

MA - Malheur NF

MH - Mt. Hood NF

U - Umatilla Indian Reservation

UM - Umatilla NF

W - Warm Springs Indian Reservation

WW - Wallowa-Whitman NF

Y - Yakima Indian Reservation

3/ More detailed information on fiber impactsand the results of alternative discount rates is available for examination at the offices of Forest Pest Management, Pacific Northwest Region, Portland, Oregon.

The tables contain various cost-benefit information for differing sets of economic assumptions. Each table also displays the major landowners in each analysis unit, number of acres considered for treatment, a projection of volume loss with no treatment, and the cost of treatment at the projected per acre rate.

Treatment and Protection Costs

A distinction is made between treatment and protection cost. This disparity figures prominently in determining the economic efficiency criteria. Total expected protection costs over the life of the outbreak may exceed initial treatment cost. The magnitude of the difference will depend on the projected need for treatments later in the infestation. The expectation of incurring future treatment costs is based on the proportion of acres in an analysis unit that have been infested less than four years. A unit which has been infested for four or more years in its entirety is projected to need only one treatment before the end of the infestation. Recently infested units are projected to need two treatments to effect adequate protection until the outbreak collapses. Units which have a mixture of acres at different years of the infestation are projected to need a second treatment with a chance proportional to the number of acres that are newly infested.

Total protection costs are used in the computation of economic efficiency statistics: present net value (PNV) and benefit-cost ratio (B/C). These costs are displayed in Tables 3-5.5/ Tables 6-8 contain treatment cost for only the initial 1988 application. Where multiple treatments are expected or have a chance to be applied for a particular analysis unit, treatment cost will be displayed differently in the two sets of tables. The difference in treatment costs between Tables 3-5 and Tables 6-8 measures the expected need for additional protection expenditures subsequent to the initial application.

Economic Opportunities

Considering all analysis units together, the number of acres where fiber benefits are projected to exceed protection costs ranges from 753,000 to 1,519,000 when discounting future values at a 4 percent rate. The range results from different assumptions regarding the annual rise in future real stumpage prices and in per acre treatment costs. Table 1 shows the total number of acres where benefits exceed costs for various combinations of treatment costs and real price increase assumptions. Figure 1 displays this same information graphically. Tables 3-8 provide detailed economic information by analysis unit and alternative stumpage price increase, treatment and discount rate assumptions.

Table 1. Acres in Oregon and Washington with B/C Ratio Greater than 1.0 by Annual Real Price Growth and Treatment Cost.

Annual Real Price Growth	Treatment Costs per Acre		
	$16.50	$19.00	$21.50
	(1000s of acres)		
0%	922	753	753
1%	1437	1313	973
2%	1437	1437	1437
3%	1519	1519	1437

The most common expectation among possible assumptions is for an application cost of $19.00 per acre and real annual stumpage price increases of 1 percent. Four percent is the primary discount rate to be considered. Under this combination of cost, price and discount rate assumptions, about 1.3 million budworm infested acres provide a better than break-even economic opportunity to avert future fiber impacts as shown in Table 1.

Other assumptions are analyzed to determine the sensitivity of the efficiency criteria to various degrees of uncertainty. Lowering treatment costs to $16.50 per acre would increase all benefit-cost ratios and add 2 analysis units and about 124,000 acres to the better than breakeven economic investment category (see Tables 2 and 3). Higher expected stumpage real price growth would also increase the number of acres with B/Cs greater than 1.0 as can be noted in Table 1.

Volume Impacts

For all 21 analysis units, impact projections estimate preventable fiber impacts over a 70 year horizon to be approximately 1.5 billion board feet. This amounts to about 933 board feet per acre or 13.3 board feet per acre per year. The value of this volume in 1987 dollars is $80 million.

Considering just those units with B/C ratios greater than 1.0, Table 2 shows the volume at risk by real annual stumpage price increase and per acre treatment cost assumptions. Volume at risk ranges from 965 million BF to 1,497 million BF. Under the most likely set of price and cost assumptions, about 1.4 billion BF in total fiber impacts or 1067 BF per acre can be protected by means of budworm treatment over the course of the infestation.

Table 2. Volume at Risk for Analysis Units with B/C Ratios Greater than 1.0 by Annual Real Price Growth and Treatment Cost.

Annual Real Price Growth	Treatment Costs per Acre		
	$16.50	$19.00	$21.50
	(MBF)		
0%	1,116,617	965,044	965,044
1%	1,462,169	1,401,952	1,166,434
2%	1,462,169	1,462,169	1,462,169
3%	1,497,046	1,497,046	1,462,169

Economic and Timber Volume Statistics by Analysis Unit

Tables 3-8 provide summary cost-benefit statistics for each analysis unit. Tables 3-5 display benefit-cost ratios (B/C) and present net value (PNV) for the three treatment cost scenarios: $16.50, $19.00 and $21.50. Within each of these tables, B/C and PNV is also displayed by the four stumpage price increase scenarios: 0, 1, 2, and 3 percent. Treatment cost in Tables 3-5 reflect expected costs arising from chance that additional treatment will be needed in subsequent years. Tables 6-8 show treatment costs for just the first treatment.

The ranking of analysis units by B/C does not change for alternative per acre costs of treatment. Higher per acre treatment cost reduces the B/C of each analysis unit proportionately. This does not affect the relative ranking of analysis units. Analysis units on the Mt. Hood National Forest and the Simcoe AU in Washington dominate the higher B/C ranks for all cost and price increase scenarios.

However, the B/C ratios of several AUs show substantial sensitivity to changes in real annual stumpage price growth rates. Analysis units expecting large volume losses in the distant future typically have the value of those losses diminished substantially by the economic discounting process. At the 0 percent stumpage price increase scenario, these units will be low in the overall ranking of analysis units. But a 3 percent real annual stumpage price increase largely offsets the effect of the 4 percent economic discounting process. As a result, units with large volume losses in the distant future rise dramatically in the ranking. Jefferson and Wilson AUs on the Warm Springs Indian Reservation are cases in point moving from 12th and 13th to 7th and 8th places. From another perspective, B/C rankings under the 3 percent stumpage price appreciation assumption come very close to ranking units on the basis of cost effectiveness, i.e., volume saved per dollar of treatment cost.

Tables 6-8 provide information showing the sensitivity of the economic statistics to different discount rates: 4, 7.125 and 10 percent. This information is displayed for three treatment cost scenarios. However, real annual stumpage price increases are maintained in these tables at the 1 percent annual rate.

Volume at risk per acre can be computed from data in Tables 6-8 using data from the ACRES TREATED and VOLUME LOSS columns. From a purely timber production protection viewpoint, analysis units on the Mt. Hood NF offer the best investment opportunities. For example, The Dalles and White River exhibit per acre volumes at risk of 1743 and 1679 BF, respectively. Jubilee on the Umatilla NF is projected to have 1230 BF volume per acre at risk.

Table 3. Economic Statistics by Real Annual Stumpage Price Increase.*

(Discount rate: 4% & Treatment cost: $16.50)

ANALYSIS UNIT	MANAGER	ACRES	TRT COST	ANNUAL % REAL STUMPAGE PRICE INCREASE 0% (PNV)	0% (B/C)	1% (PNV)	1% (B/C)	2% (PNV)	2% (B/C)	3% (PNV)	3% (B/C)
BARLOW	MH S	83580	1434231+	2178193	2.52	3662900	3.55	6061875	5.23	10074206	8.02
WHITE RIVER	MH S	188807	5450141+	7611072	2.40	12891529	3.37	21638235	4.97	36743830	7.74
THE DALLES	MH S	122723	3446612+	4652116	2.35	7375716	3.14	11312860	4.28	17190667	5.99
HIGHROCK	MH	73809	2136474+	2598200	2.22	4747094	3.22	8419744	4.94	14927001	7.99
SIMCOE	Y S	109867	1931630+	2276234	2.18	3469505	2.80	5091973	3.64	7319835	4.79
MT. HOOD	MH S	110434	3189526+	3696432	2.16	6661582	3.09	11625050	4.64	20229221	7.34
MEACHAM	UM U S	64024	1564044+	531317	1.34	1015514	1.65	1688824	2.08	2663701	2.70
JUBILEE	UM	92689	2542002+	330230	1.13	1429649	1.56	3225241	2.27	6281068	3.47
MILL	UM S	76336	1601391+	29326	1.02	518855	1.32	1191260	1.74	2119626	2.32
HUCKLEBERRY	UM U S	85968	2055058+	-67625	.97	552541	1.27	1478014	1.72	2899095	2.41
TARGET	UM S	65060	1558473+	-112480	.93	346392	1.22	1041432	1.67	2134410	2.37
JEFFERSON	W	50883	1083081+	-110034	.90	389458	1.36	1375860	2.27	3438752	4.17
WILSON	W	75937	1303075+	-147511	.89	335562	1.26	1288499	1.99	3293357	3.53
RUCKEL	UM S	112982	2702235+	-310063	.89	537220	1.20	1869627	1.69	4045346	2.50
HEHE BUTTE	W	59512	1202689+	-260536	.78	36273	1.03	543483	1.45	1491083	2.24
SHITIKE BUTTE	W	64227	1298026+	-328600	.75	63375	1.05	762103	1.59	2106806	2.62
SOUTH N.R.A.	WW S	82235	2234376+	-970857	.57	-604727	.73	-109847	.95	567707	1.25
WATERSHED	UM S U	18866	325944+	-228199	.30	-195437	.40	-147755	.55	-76699	.76
REYNOLDS	MA S	35999	617739+	-501018	.19	-435193	.30	-330001	.47	-159585	.74
STARKEY	WW	15800	271127+	-255664	.06	-255456	.06	-255581	.06	-256300	.05
BRIDGE	MA	23487	403036+	-403036	.00	-403036	.00	-403036	.00	-403036	.00

+ TREATMENT COST INCLUDES AN ADJUSTMENT FOR MULTIPLE TREATMENTS.
* ALL VALUES ARE EXPRESSED IN 1987 DOLLARS.

Table 4. Economic Statistics by Real Annual Stumpage Price Increase.

(Discount rate: 4% & Treatment cost: $19.00)

ANALYSIS UNIT	MANAGER	ACRES	TRT COST	ANNUAL % REAL STUMPAGE PRICE INCREASE 0%		1%		2%		3%	
				(PNV)	(B/C)	(PNV)	(B/C)	(PNV)	(B/C)	(PNV)	(B/C)
BARLOW	MH S	83580	1651536+	1960888	2.19	3445595	3.09	5844570	4.54	9856901	6.97
WHITE RIVER	MH S	188807	6275919+	6785294	2.0812065751		2.92	20812457	4.32	35918052	6.72
THE DALLES	MH S	122723	3968826+	4129902	2.04	6853502	2.73	10790646	3.72	16668453	5.20
HIGHROCK	MH	73809	2460185+	2274489	1.92	4423383	2.80	8096033	4.29	14603290	6.94
SIMCOE	Y S	109867	2224296+	1983568	1.89	3176839	2.43	4799307	3.16	7027169	4.16
MT. HOOD	MH S	110434	3672785+	3213173	1.87	6178323	2.68	11141791	4.03	19745962	6.38
MEACHAM	UM U S	64024	1801007+	294354	1.16	778551	1.43	1451861	1.81	2426738	2.35
JUBILEE	UM	92689	2927158+	-54925	.98	1044493	1.36	2840085	1.97	5895912	3.01
MILL	UM S	76336	1844037+	-213319	.88	276209	1.15	948614	1.51	1876980	2.02
HUCKLEBERRY	UM U S	85968	2366434+	-379001	.84	241165	1.10	1166638	1.49	2587719	2.09
TARGET	UM S	65060	1794594+	-348601	.81	110271	1.06	805311	1.45	1898289	2.06
JEFFERSON	W	50883	1247182+	-274135	.78	225357	1.18	1211759	1.97	3274651	3.63
WILSON	W	75937	1500512+	-344948	.77	138125	1.09	1091062	1.73	3095920	3.06
RUCKEL	UM S	112982	3111660+	-719488	.77	127795	1.04	1460202	1.47	3635921	2.17
HEHE BUTTE	W	59512	1384913+	-442760	.68	-145950	.89	361259	1.26	1308859	1.95
SHITIKE BUTTE	W	64227	1494699+	-525273	.65	-133297	.91	565430	1.38	1910133	2.28
SOUTH N.R.A.	WW S	82235	2572926+	-1309407	.49	-943277	.63	-448397	.83	229157	1.09
WATERSHED	UM S U	18866	375315+	-277570	.26	-244808	.35	-197126	.47	-126070	.66
REYNOLDS	MA S	35999	711340+	-594619	.16	-528794	.26	-423602	.40	-253186	.64
STARKEY	WW	15800	312212+	-296749	.05	-296541	.05	-296666	.05	-297385	.05
BRIDGE	MA	23487	464103+	-464103	.00	-464103	.00	-464103	.00	-464103	.00

+ TREATMENT COST INCLUDES AN ADJUSTMENT FOR MULTIPLE TREATMENTS.
* ALL VALUES ARE EXPRESSED IN 1987 DOLLARS.

Table 5. Economic Statistics by Real Annual Stumpage Price Increase.*

(Discount rate: 4% & Treatment cost: $21.00)

ANALYSIS UNIT	MANAGER	ACRES	TRT COST	- - - - ANNUAL % REAL STUMPAGE PRICE INCREASE - - - - 0%		1%		2%		3%	
				(PNV)	(B/C)	(PNV)	(B/C)	(PNV)	(B/C)	(PNV)	(B/C)
BARLOW	MH S	83580	1868852+	1743572	1.93	3228279	2.73	5627254	4.01	9639585	6.16
WHITE RIVER	MH S	188807	7101699+	5959514	1.84	11239971	2.58	19986677	3.81	35092272	5.94
THE DALLES	MH S	122723	4491043+	3607685	1.80	6331285	2.41	10268429	3.29	16146236	4.60
HIGHROCK	MH	73809	2783892+	1950782	1.70	4099676	2.47	7772326	3.79	14279583	6.13
SIMCOE	Y S	109867	2516973+	1690891	1.67	2884162	2.15	4506630	2.79	6734492	3.68
MT. HOOD	MH S	110434	4156051+	2729907	1.66	5695057	2.37	10658525	3.56	19262696	5.63
MEACHAM	UM U S	64024	2037990+	57371	1.03	541568	1.27	1214878	1.60	2189755	2.07
JUBILEE	UM	92689	3312318+	-440085	.87	659333	1.20	2454925	1.74	5510752	2.66
MILL	UM S	76336	2086665+	-455947	.78	33581	1.02	705986	1.34	1634352	1.78
HUCKLEBERRY	UM U S	85968	2677808+	-690375	.74	-70208	.97	855264	1.32	2276345	1.85
TARGET	UM S	65060	2030734+	-584741	.71	-125868	.94	569171	1.28	1662149	1.82
JEFFERSON	W	50883	1411284+	-438237	.69	61255	1.04	1047657	1.74	3110549	3.20
WILSON	W	75937	1697949+	-542385	.68	-59311	.97	893625	1.53	2898483	2.71
RUCKEL	UM S	112982	3521088+	-1128916	.68	-281632	.92	1050774	1.30	3226493	1.92
HEHE BUTTE	W	59512	1567133+	-624980	.60	-328170	.79	179039	1.11	1126639	1.72
SHITIKE BUTTE	W	64227	1691368+	-721942	.57	-329966	.80	368761	1.22	1713464	2.01
SOUTH N.R.A.	WW S	82235	2911471+	-1647952	.43	-1281822	.56	-786942	.73	-109387	.96
WATERSHED	UM S U	18866	424707+	-326962	.23	-294200	.31	-246518	.42	-175462	.59
REYNOLDS	MA S	35999	804936+	-688215	.15	-622390	.23	-517198	.36	-346782	.57
STARKEY	WW	15800	353291+	-337828	.04	-337620	.04	-337745	.04	-338464	.04
BRIDGE	MA	23487	525170+	-525170	.00	-525170	.00	-525170	.00	-525170	.00

+ TREATMENT COST INCLUDES AN ADJUSTMENT FOR MULTIPLE TREATMENTS.
* ALL VALUES ARE EXPRESSED IN 1987 DOLLARS.

Table 6. Economic Projections by Alternative Discount Rate.*

(Treatment cost: $16.50 & Real stumpage increase: 1%)

ANALYSIS UNIT	LAND MANAGER	ACRES TREATED	VOLUME LOSS	TREATMENT COST	DISCOUNT RATES 4-PERCENT		7&1/8-PERCENT		10-PERCENT	
(NAME)	(CODE)	(ACRES)	(MBF)	(DOLLARS)	(PNV)	(B/C)	(PNV)	(B/C)	(PNV)	(B/C)
BARLOW	MH S	83580	87596	1379070	3662900	3.55	979654	1.66	110854	1.07
WHITE RIVER	MH S	188807	307619	3115315	12891529	3.37	3697707	1.68	916550	1.17
HIGHROCK	MH	73809	128675	1217848	4747094	3.22	1017980	1.48	-5262	1.00
THE DALLES	MH S	122723	138324	2024929	7375716	3.14	2324706	1.68	222755	1.07
MT. HOOD	MH S	110434	171421	1822161	6661582	3.09	1495095	1.47	9891	1.00
SIMCOE	Y S	109867	89958	1812805	3469505	2.80	1222957	1.62	201619	1.10
MEACHAM	UM U S	64024	41451	1056396	1015514	1.65	184129	1.12	-206840	.87
JUBILEE	UM	92689	113978	1529368	1429649	1.56	-482674	.81	-1091804	.57
JEFFERSON	W	50883	49817	839569	389458	1.36	-447567	.59	-655713	.41
MILL	UM S	76336	37595	1259544	518855	1.32	-408651	.75	-818892	.50
HUCKLEBERRY	UM U S	85968	57515	1418472	552541	1.27	-551886	.73	-974107	.53
WILSON	W	75937	49431	1252960	335562	1.26	-470339	.65	-689306	.50
TARGET	UM S	65060	44418	1073490	346392	1.22	-470222	.70	-783323	.50
RUCKEL	UM S	112982	84154	1864203	537220	1.20	-968296	.64	-1496254	.45
SHITIKE BUTTE	W	64227	34406	1059745	63375	1.05	-623558	.53	-840005	.37
HEHE BUTTE	W	59512	25811	981948	36273	1.03	-474270	.61	-657063	.47
SOUTH N.R.A.	WW S	82235	34877	1356877	-604727	.73	-1283616	.42	-1597469	.28
WATERSHED	UM S U	18866	2177	311289	-195437	.40	-265199	.21	-298041	.13
REYNOLDS	MA S	35999	6227	593983	-435193	.30	-576804	.09	-629416	.04
STARKEY	WW	15800	153	260700	-255456	.06	-261806	.06	-268153	.06
BRIDGE	MA	23487	0	387535	-403036	.00	-415146	.00	-426289	.00
TOTAL		1613225	1505603	26618207	42139316	2.10	3222194	1.08	-9976268	.74

* ALL VALUES ARE EXPRESSED IN 1987 DOLLARS.

Table 7. Economic Projections by Alternative Discount Rate.*

(Treatment cost: $19.00 & Real stumpage increase: 1%)

ANALYSIS UNIT	LAND MANAGER	ACRES TREATED	VOLUME LOSS	TREATMENT COST	DISCOUNT RATES 4-PERCENT		7&1/8-PERCENT		10-PERCENT	
(NAME)	(CODE)	(ACRES)	(MBF)	(DOLLARS)	(PNV)	(B/C)	(PNV)	(B/C)	(PNV)	(B/C)
BARLOW	MH S	83580	87596	1588020	3445595	3.09	755816	1.44	-118987	.93
WHITE RIVER	MH S	188807	307619	3587333	12065751	2.92	2876424	1.46	97995	1.02
HIGHROCK	MH	73809	128675	1402371	4423383	2.80	696082	1.28	-326050	.87
THE DALLES	MH S	122723	138324	2331737	6853502	2.73	1804578	1.46	-296312	.92
MT. HOOD	MH S	110434	171421	2098246	6178323	2.68	1014486	1.28	-469121	.87
SIMCOE	Y S	109867	89958	2087473	3176839	2.43	922104	1.40	-106789	.95
MEACHAM	UM U S	64024	41451	1216456	778551	1.43	-53808	.97	-445953	.75
JUBILEE	UM	92689	113978	1761091	1044493	1.36	-866784	.70	-1475576	.49
JEFFERSON	W	50883	49817	966777	225357	1.18	-613818	.51	-824074	.36
MILL	UM S	76336	37595	1450384	276209	1.15	-654713	.65	-1068284	.44
HUCKLEBERRY	UM U S	85968	57515	1633392	241165	1.10	-864923	.64	-1289053	.46
WILSON	W	75937	49431	1442803	138125	1.09	-673701	.56	-898127	.43
TARGET	UM S	65060	44418	1236140	110271	1.06	-707585	.61	-1022097	.44
RUCKEL	UM S	112982	84154	2146658	127795	1.04	-1379904	.56	-1910344	.39
SHITIKE BUTTE	W	64227	34406	1220313	-133297	.91	-823540	.46	-1043162	.32
HEHE BUTTE	W	59512	25811	1130728	-145950	.89	-659565	.53	-845297	.41
SOUTH N.R.A.	WW S	82235	34877	1562465	-943277	.63	-1621409	.37	-1935112	.25
WATERSHED	UM S U	18866	2177	358454	-244808	.35	-316031	.18	-350224	.12
REYNOLDS	MA S	35999	6227	683981	-528794	.26	-673215	.08	-728417	.03
STARKEY	WW	15800	153	300200	-296541	.05	-304123	.05	-311597	.06
BRIDGE	MA	23487	0	446253	-464103	.00	-478048	.00	-490878	.00
TOTAL		1613225	1505603	30651275	36328589	1.82	-2621677	.94	-15857459	.65

* ALL VALUES ARE EXPRESSED IN 1987 DOLLARS.

Table 8. Economic Projections by Alternative Discount Rate.*

(Treatment cost: $21.50 & Real stumpage increase: 1%)

ANALYSIS UNIT	LAND MANAGER	ACRES TREATED	VOLUME LOSS	TREATMENT COST	DISCOUNT RATES 4-PERCENT		7&1/8-PERCENT		10-PERCENT	
(NAME)	(CODE)	(ACRES)	(MBF)	(DOLLARS)	(PNV)	(B/C)	(PNV)	(B/C)	(PNV)	(B/C)
BARLOW	MH S	83580	87596	1796970	3228279	2.73	531982	1.28	-348831	.82
WHITE RIVER	MH S	188807	307619	4059350	11239971	2.58	2055147	1.29	-720569	.90
HIGHROCK	MH	73809	128675	1586893	4099676	2.47	374186	1.14	-646843	.77
THE DALLES	MH S	122723	138324	2638544	6331285	2.41	1284461	1.29	-815382	.82
MT. HOOD	MH S	110434	171421	2374331	5695057	2.37	533873	1.13	-948132	.77
SIMCOE	Y S	109867	89958	2362140	2884162	2.15	621253	1.24	-415192	.84
MEACHAM	UM U S	64024	41451	1376516	541568	1.27	-291732	.86	-685049	.67
JUBILEE	UM	92689	113978	1992813	659333	1.20	-1250884	.62	-1859329	.44
JEFFERSON	W	50883	49817	1093984	61255	1.04	-780064	.45	-992430	.31
MILL	UM S	76336	37595	1641224	33581	1.02	-900781	.57	-1317687	.39
HUCKLEBERRY	UM U S	85968	57515	1848312	-70208	.97	-1177972	.56	-1603999	.41
WILSON	W	75937	49431	1632645	-59311	.97	-877077	.50	-1106954	.38
TARGET	UM S	65060	44418	1398790	-125868	.94	-944938	.54	-1260883	.39
RUCKEL	UM S	112982	84154	2429113	-281632	.92	-1791505	.49	-2324445	.35
SHITTIKE BUTTE	W	64227	34406	1380880	-329966	.80	-1023525	.40	-1246314	.29
HEHE BUTTE	W	59512	25811	1279508	-328170	.79	-844858	.47	-1033532	.36
SOUTH N.R.A.	WW S	82235	34877	1768052	-1281822	.56	-1959208	.33	-2272749	.22
WATERSHED	UM S U	18866	2177	405619	-294200	.31	-366882	.16	-402399	.10
REYNOLDS	MA S	35999	6227	773978	-622390	.23	-769626	.07	-827409	.03
STARKEY	WW	15800	153	339700	-337620	.04	-346435	.05	-355051	.05
BRIDGE	MA	23487	0	504970	-525170	.00	-540948	.00	-555468	.00
TOTAL		1613225	1505603	34684332	30517810	1.61	-8465533	.83	-21738647	.57

* ALL VALUES ARE EXPRESSED IN 1987 DOLLARS.

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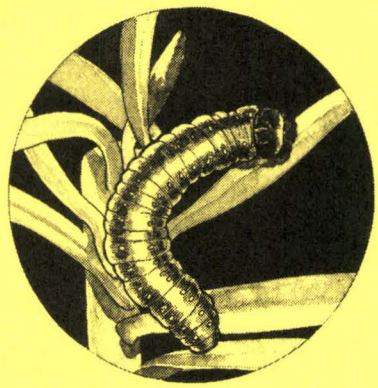
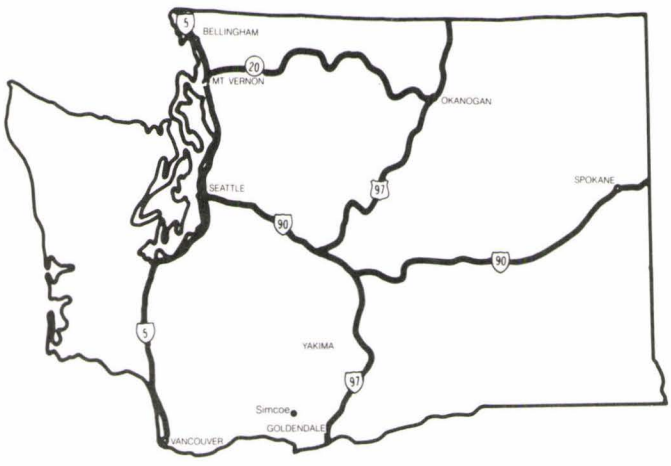


Appendix D
Maps of Analysis Units



Yakima Indian Reservation
and adjacent lands

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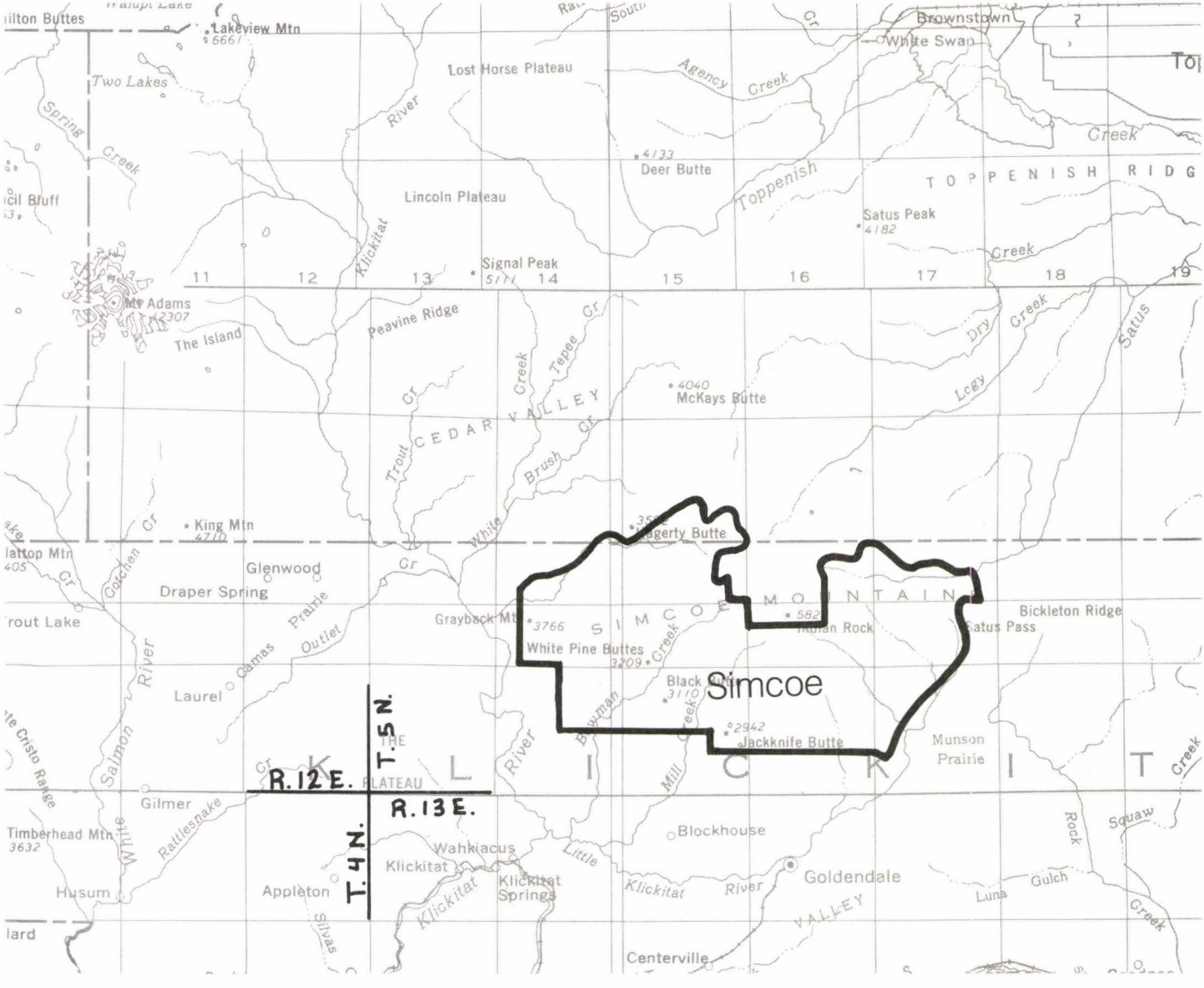

Malheur National Forest
and adjacent lands

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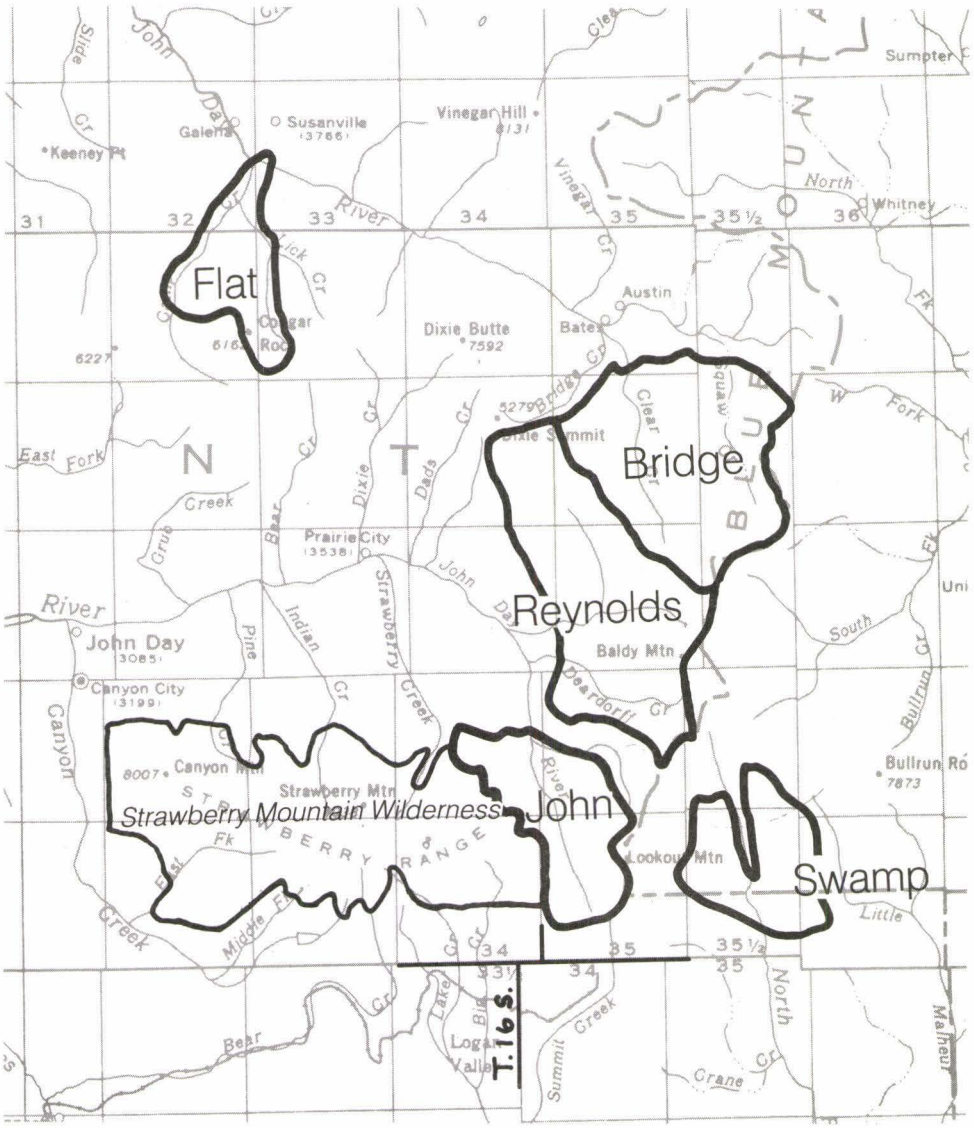

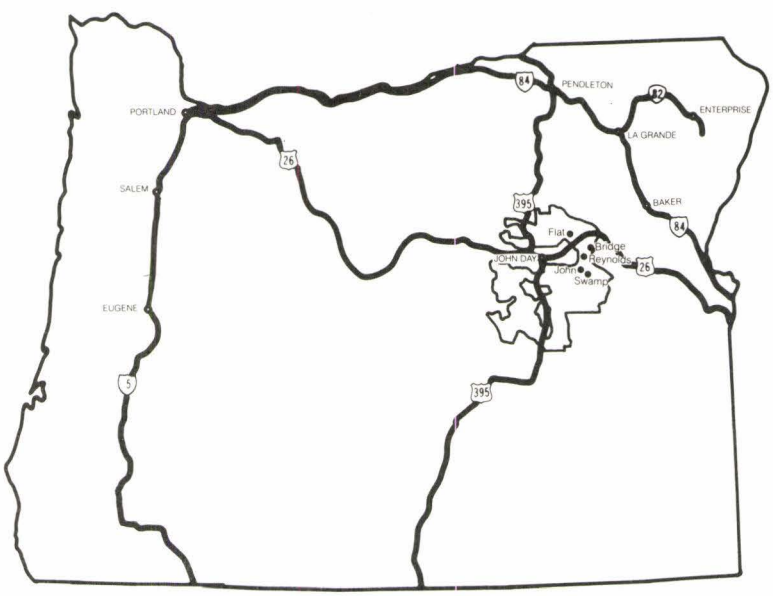

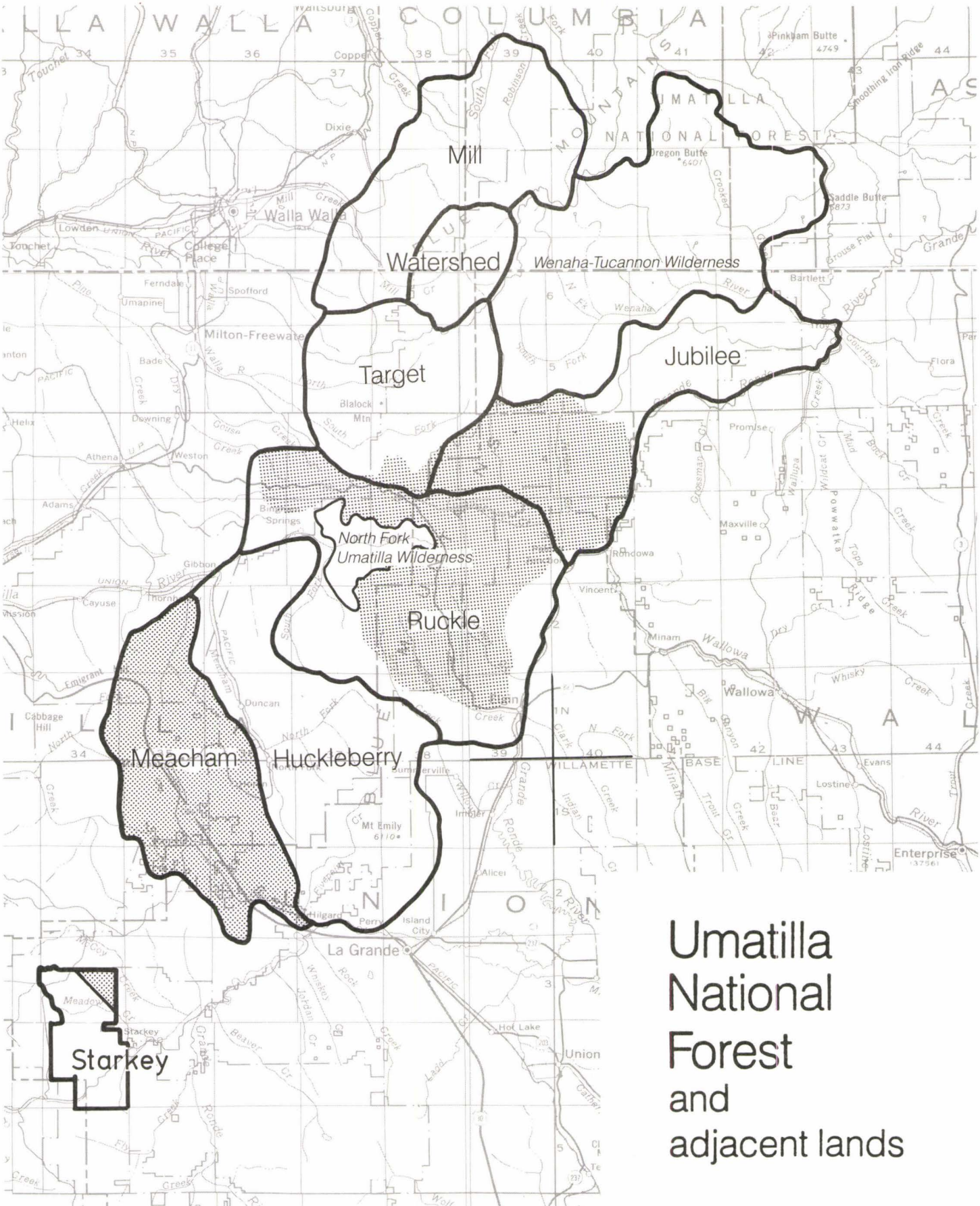

Umatilla National Forest
and adjacent lands

LEGEND

- treatment
- no treatment

Scale
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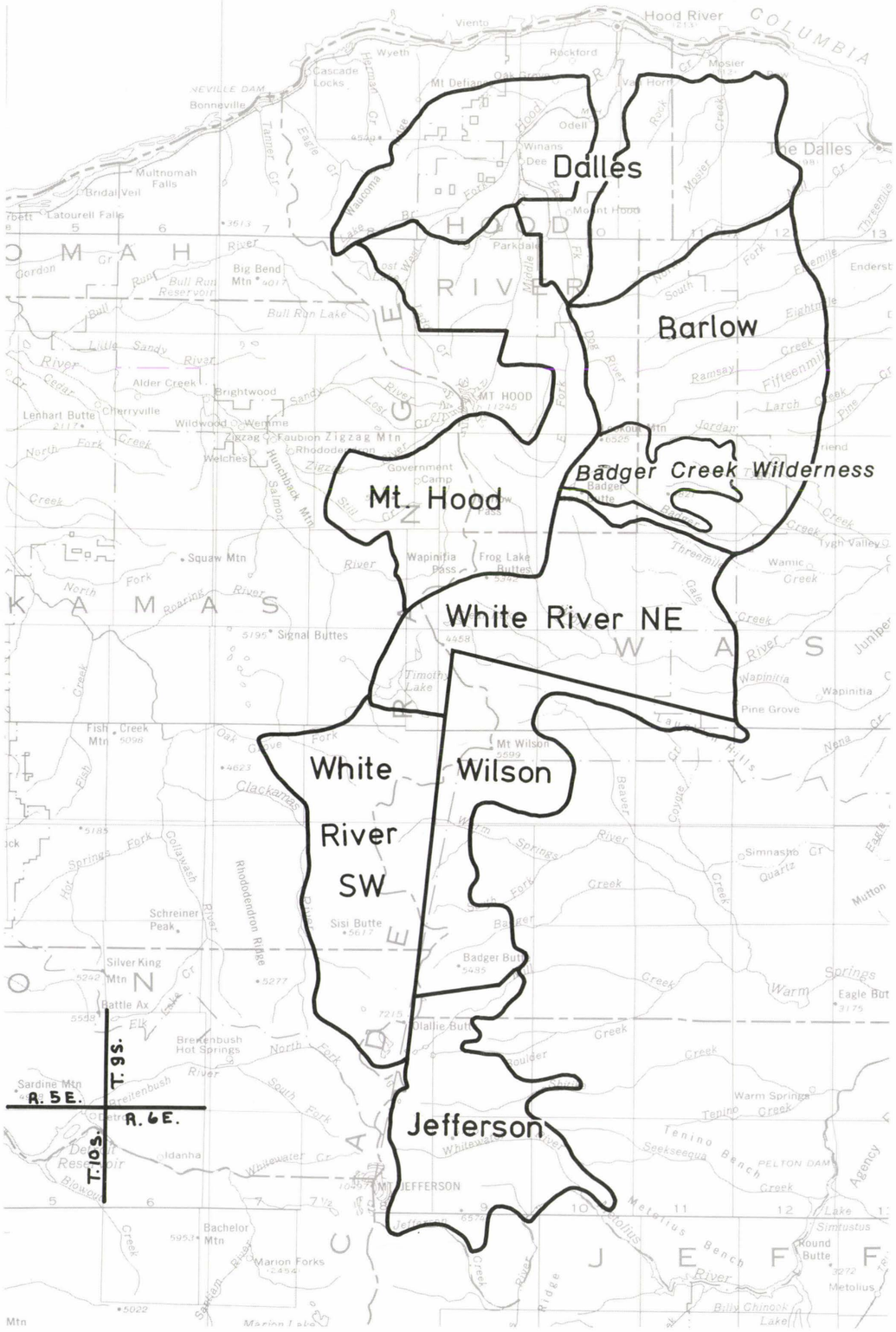
¾" = Approx. 6 mi.

Mt. Hood National Forest and Warm Springs Indian Reservation



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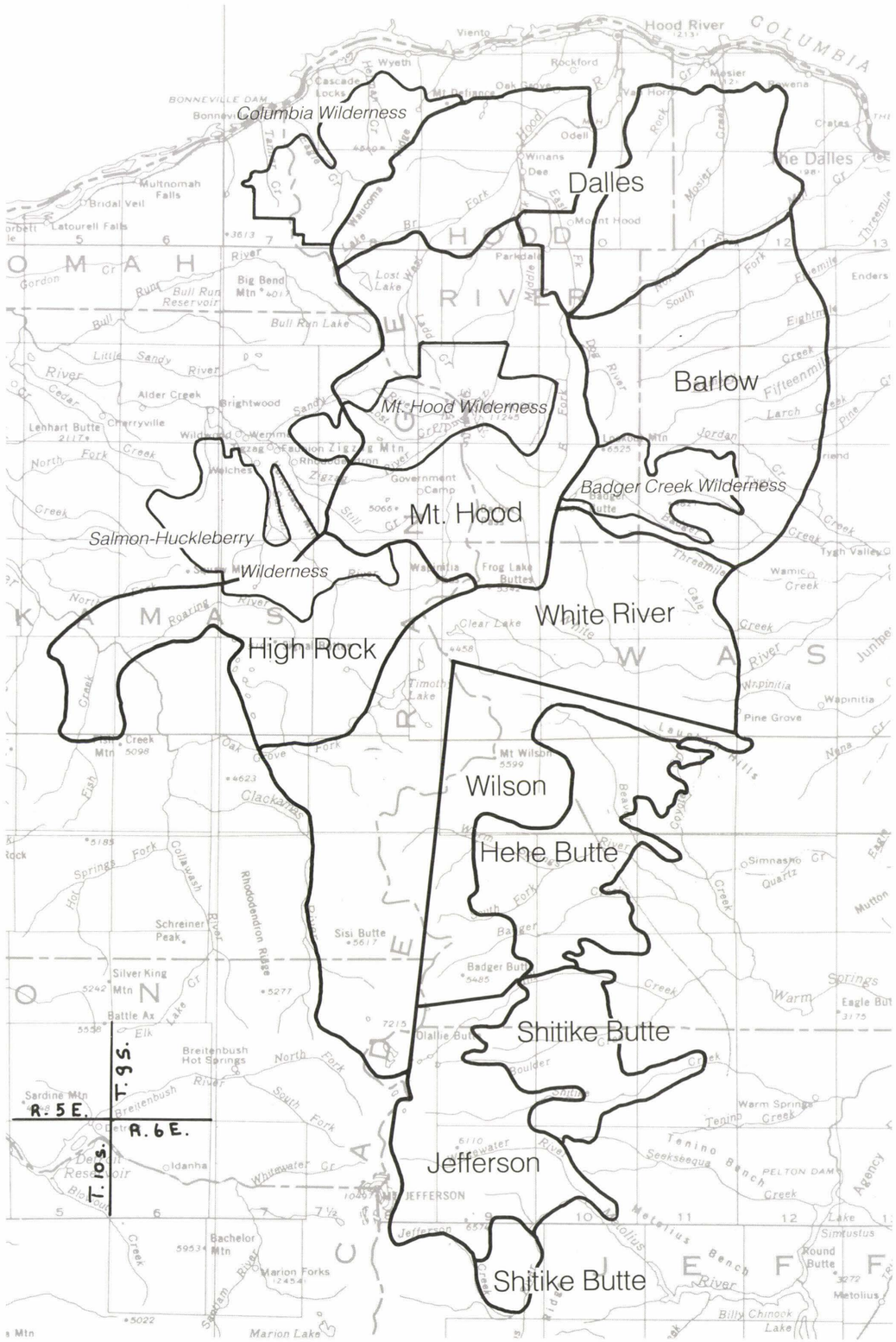
Mt. Hood National Forest and Warm Springs Indian Reservation



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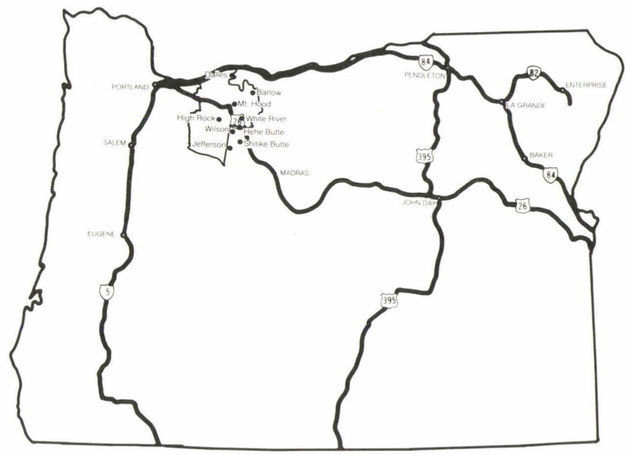
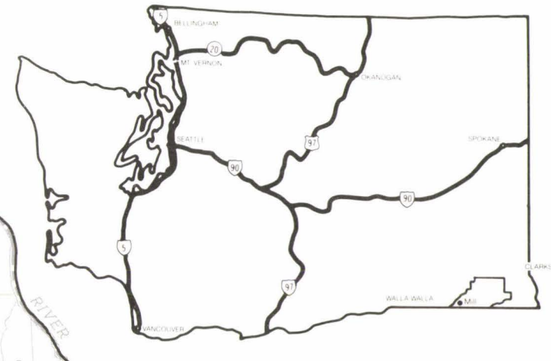


Umatilla and Wallowa-Whitman National Forests and adjacent lands



Scale
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¾" = Approx. 6 mi.

Mill

Watershed

Wenaha-Tucannon Wilderness

Target

Jubilee

North Fork Umatilla Wilderness

Ruckle

Meacham

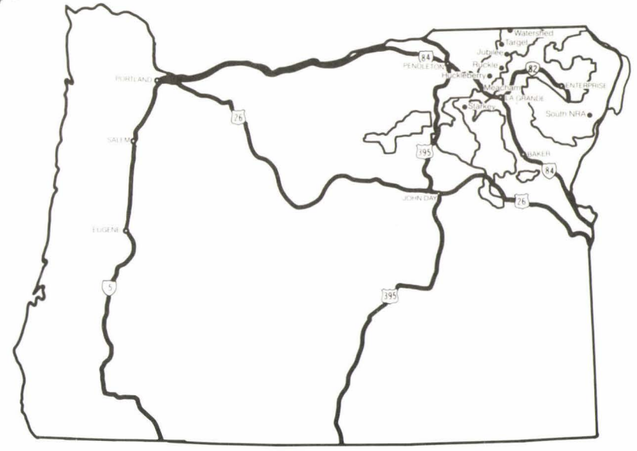
Huckleberry

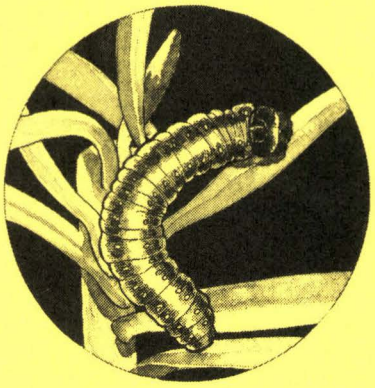
Starkey

Eagle Cap Wilderness

Hells Canyon Wilderness

South NRA





Appendix E
Methods used for Estimating Timber Volume Losses caused by a Western Spruce Budworm Outbreak

APPENDIX E

METHODS USED FOR ESTIMATING TIMBER VOLUME LOSSES CAUSED BY A WESTERN SPRUCE BUDWORM OUTBREAK

The methods used for estimating the western spruce budworm-caused timber volume losses for this Environmental Assessment incorporated the use of two computer simulation models. Version 5.1 of the PROGNOSIS model for forest stand development (Stage 1973), which is basicly a "tree-growing" model, was linked to a budworm damage submodel which was developed through the Canadian/U.S. (CANUSA) Spruce Budworm Research Program.

Tree data used in the analysis were obtained from the most current forest inventory of stand conditions. For National Forest System, State of Oregon, and private lands, data were taken from the latest Forest-wide inventory most of which are updated every 10 years. Boise Cascade Corporation and Champion Timberlands supplied their own tree data for their lands in the Simcoe Analysis Unit as did the Warm Springs Indian Reservation for their analysis units.

These inventory data were then segregated by the management needs of the appropriate land managers into components of an overall forest yield model. The five general categories of management needs are: (1) stands in need of regeneration; (2) stands in need of commercial thinning; (3) stands in need of precommercial thinning, (4) stands in need of overstory removal; and (5) stands where no management is planned. National Forests built an "average" stand for each model component in one of two ways: 1) by using tree data from the first three points of all forest inventory plots which represent a particular model component, or 2) by selecting a subset of the inventory plots which would better represent the stands in a model component in the areas being analyzed. For National Forest lands, FORPLAN, a harvest scheduling model in use by the National Forests, was used to generate an optimum schedule of stand entries over time with the objective of maximizing present net worth of timber volume removed. An example of scheduled management needs for the Malheur National Forest is shown in Table 1. The schedules of stand entries for State and private lands were provided by State personnel with the exception of Indian Reservation lands. Those schedules were provided by Bureau of Indian Affairs personnel.

These inventory plot data were used as input to the stand prognosis model which was used to project volume growth over time until the final harvest. For each analysis unit, volume growth was projected for each model component using the stand prognosis model linked to the budworm damage submodel for each of several scenarios: untreated 10-year outbreak with light (U10L), moderate (U10M), or heavy (U10H) damage; treatment in the first year of visible defoliation in outbreaks projected to have light (T1 L), moderate (T1 M), or heavy (T1 H) damage, treatment in the second year of visible defoliation (T2 L, T2 M, T2 H), and so on (Table 2). For all of these scenarios it was assumed that the length of the outbreak would be no longer than 10 years. Other parameters which were entered into the model included the amount of current year's defoliation for each year of the outbreak (Tables 3-5) and the total amount of

top-kill projected over the outbreak period. An example of values used for top-kill parameters for several treatment scenarios in an outbreak in which moderate damage is projected appears in Table 6. The volume at risk (i.e., the volume projected in a treated infestation less the volume projected for a similar untreated infestation) was estimated each decade that harvest was simulated. The total volume at risk over the rotation period (i.e., until final harvest and starting of a new stand) was then calculated for each combination of stand type, harvest type, harvest schedule, and insecticide treatment scenario. A numerical example of volumes generated by the combined models for a mixed-conifer stand on the Malheur National Forest is shown in Table 3.

Within each analysis unit, the acreage of each model component was totaled and multiplied by the per acre volume at risk. These volumes were then added together to derive the total volume at risk for the analysis unit.

Table 1. FORPLAN generated optimal mix of scheduled management needs (rows) for forest yield model components (columns) using a maximum present net worth objective function for the Malheur National Forest.

	Mixed Conifer[1/]	Ponderosa Pine[2/]	Lodgepole Pine[3]
Regeneration	Final harvest, decades 4-8	Final harvest, decades 4-8	Final harvest, decades 1-2
Commercial Thin	Overstory removal, decade 2; commercial thin, decade 4; final harvest, decade 6	Overstory removal, decade 1;commercial thin,decade 3; final harvest, decade 5	Overstory removal, decade 2; final harvest, decade 6
Overstory Removal	Overstory removal, decades 1, 2, 3; final harvest, decades 4, 5	Overstory removal, decades 1, 2, 3; commercial thin, decades 4, 5, 6; final harvest, decades 6, 7, 8	Final harvest, decades 1, 2
No Treatment in First Decade	Overstory removal, decade 2; commercial thin, decade 4; final harvest, decade 6	Overstory removal, decade 3; final harvest, decade 6	Overstory removal, decade 2; commercial thin, decade 6; final harvest, decade 8

1/ Stands consist primarily of Douglas-fir and grand fir.
2/ Stands may contain up to 20% Douglas-fir and/or grand fir.
3/ Stands may contain a small percentage of Douglas-fir and/or grand fir.

Table 2. Insecticide treatment scenarios and the untreated scenarios with which they were compared to calculate volumes at risk for the 1988 environmental analysis of the western spruce budworm situation in the Pacific Northwest Region.

TREATMENT SCENARIO	YEAR(S) OF TREATMENT[1/]	UNTREATED SCENARIO	LENGTH OF OUTBREAK	PROJECTED DAMAGE
T1 L	1	U10L	10	Light
T1 M	1,4	U10L	10	Moderate
T1 H	1,4	U10L	10	Heavy
T2 L	2	U10L	10	Light
T2 M	2,5	U10L	10	Moderate
T2 H	2,5	U10L	10	Heavy
T3 L	3	U10L	10	Light
T3 M	3,6	U10L	10	Moderate
T3 H	3,6	U10L	10	Heavy
T4 L	4	U10L	10	Light
T4 M	4,7	U10L	10	Moderate
T4 H	4,7	U10L	10	Heavy
T5 L	5	U10L	10	Light
T5 M	5	U10L	10	Moderate
T5 H	5	U10L	10	Heavy
T6 L	6	U10L	10	Light
T6 M	6	U10L	10	Moderate
T6 H	6	U10L	10	Heavy
T7 L	7	U10L	10	Light
T7 M	7	U10L	10	Moderate
T7 H	7	U10L	10	Heavy

1/ These are the years in which insecticide treatment is projected (i.e., 2 indicates treatment in the second year that defoliation is visible during an aerial detection survey); note that some scenarios have two treatments during the course of the outbreak.

Table 3. Western spruce budworm defoliation scenarios for insecticide treated and untreated Douglas-fir and grand fir in an outbreak in which light damage is predicted for the untreated scenario; 1988 analysis of the budworm situation in the Pacific Northwest Region.

	Treatment Scenario							
	U10L	T1 L	T2 L	T3 L	T4 L	T5 L	T6 L	T7 L
Year of Outbreak	Defoliation[1/]							
1	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10
2	40/50	35/45*	40/50	40/50	40/50	40/50	40/50	40/50
3	60/70	15/15	55/65*	60/70	60/70	60/70	60/70	60/70
4	70/75	25/25	15/15	65/70*	70/75	70/75	70/75	70/75
5	70/80	50/50	25/25	15/15	65/75*	70/80	70/80	70/80
6	70/75	60/60	50/50	25/25	15/15	65/70*	70/75	70/75
7	60/60	60/60	60/60	50/50	25/25	15/15	55/55*	60/60
8	50/50	50/50	50/50	50/50	50/50	25/25	15/15	45/45*
9	20/20	20/20	20/20	20/20	20/20	20/20	20/20	15/15
10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10

1/ The number before the slash is percent defoliation of current year's foliage on Douglas-fir and the number after the slash is for grand fir; an asterisk (*) indicates insecticide treatment in that year of the outbreak.

Table 4. Western spruce budworm defoliation scenarios for insecticide treated and untreated Douglas-fir and grand fir in an outbreak in which moderate damage is predicted for the untreated scenario; 1988 analysis of the budworm situation in the Pacific Northwest Region.

	Treatment Scenario							
	U10M	T1 M	T2 M	T3 M	T4 M	T5 M	T6 M	T7 M
Year of Outbreak	Defoliation[1/]							
1	10/20	10/20	10/20	10/20	10/20	10/20	10/20	10/20
2	40/50	35/45*	40/50	40/50	40/50	40/50	40/50	40/50
3	70/80	15/15	65/75*	70/80	70/80	70/80	70/80	70/80
4	85/90	30/35	15/15	80/85*	85/90	85/90	85/90	85/90
5	85/90	65/80*	30/35	15/15	80/85*	85/90	85/90	85/90
6	85/90	15/15	65/80*	30/35	15/15	80/85*	85/90	85/90
7	85/90	30/35	15/15	65/80*	30/35	15/15	80/85*	85/90
8	50/50	65/80	30/35	15/15	45/45*	30/35	15/15	45/45*
9	20/20	20/20	20/20	20/20	15/15	20/20	20/20	15/15
10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10

1/ The number before the slash is percent defoliation of current year's foliage on Douglas-fir and the number after the slash is for grand fir; an asterisk (*) indicates insecticide treatment in that year of the outbreak.

Table 5. Western spruce budworm defoliation scenarios for insecticide treated and untreated Douglas-fir and grand fir in an outbreak in which heavy damage is predicted for the untreated scenario; 1988 analysis of the budworm situation in the Pacific Northwest Region.

	Treatment Scenario							
	U10H	T1 H	T2 H	T3 H	T4 H	T5 H	T6 H	T7 H
Year of Outbreak	Defoliation[1/]							
1	20/30	20/30	20/30	20/30	20/30	20/30	20/30	20/30
2	50/90	45/85*	50/90	50/90	50/90	50/90	50/90	50/90
3	80/99	15/15	75/94*	80/99	80/99	80/99	80/99	80/99
4	100/100	40/40	15/15	95/95*	100/100	100/100	100/100	100/100
5	100/100	90/90*	40/40	15/15	95/95*	100/100	100/100	100/100
6	100/100	15/15	90/90*	40/40	15/15	95/95*	100/100	100/100
7	100/100	40/40	15/15	90/90*	40/40	15/15	95/95*	100/100
8	80/99	90/90	40/40	15/15	70/89*	40/40	15/15	75/94*
9	50/50	50/150	50/50	40/40	15/15	50/50	40/40	15/15
10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10

1/ The number before the slash is percent defoliation of current year's foliage on Douglas-fir and the number after the slash is for grand fir; an asterisk (*) indicates insecticide treatment in that year of the outbreak.

Table 6. Amounts of top-kill projected on Douglas-fir and grand fir for several treatment scenarios of a western spruce budworm outbreak in which the predicted damage for an untreated 10-year outbreak is classified as moderate.

	TREATMENT SCENARIO						
	U10M	T2 M	T3 M	T4 M	T5 M	T6 M	T7 M
DOUGLAS-FIR[2/]	70/.20[1/]	.00/.00	.00/.00	.17/.02	.47/.04	.67/.08	.70/.20
	.77/.11	.00/.00	.00/.00	.25/.02	.55/.04	.75/.07	.77/.11
	68/.10	.00/.00	.00/.00	.05/.01	.35/.02	.55/.04	.68/.10
GRAND FIR	79/.06	.00/.00	.00/.00	.05/.01	.35/.02	.55/.04	.79/.06
	91/.11	.00/.00	.00/.00	.35/.01	.65/.02	.85/.04	.91/.11
	86/.09	.00/.00	.00/.00	.26/.01	.56/.02	.76/.04	.86/.09

1/ The number in front the slash is the projected proportion of trees that will experience top-kill; the number after the slash is the projected average proportion of the total tree height that will be killed. 2The top row after each tree species shows projected levels of top-kill for trees 0 to 23 feet tall, the middle row for trees 23 to 46 feet tall, and the bottom row for trees taller than 46 feet.

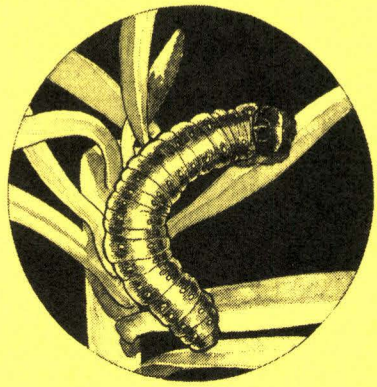
Table 7. Timber volumes (board feet) projected by a combined stand prognosis/budworm damage model for several insecticide treatment scenarios for a mixed conifer stand on the Malheur National Forest.

	INSECTICIDE TREATMENT SCENARIO									
DECADE	U10M[1/]		T4 M		T5 M		T6 M		T7 M	
1980	16332	0	16332	0	16332	0	16332	0	16332	0
1990[2/]	16552	15601	17004	14895	16849	15428	16682	15572	16554	15602
2000	1452	0	3092	0	2208	0	1713	0	1452	0
2010	2315	0	5494	0	3557	0	2946	0	2315	0
2020[3/]	4025	858	8558	2161	5651	1387	4196	1157	4025	858
2030	4632	0	8883	0	6159	0	4561	0	4632	0
2040[4/]	6860	6637	11448	11218	8416	8183	7034	6745	6859	6637
TOTAL VOLUME REMOVED		23096		28274		24998		23474		23097

1/ Numbers in the first column under each treatment scenario heading are the standing board foot wood volumes per acre at the beginning of each decade; the second column shows the amount of volume removed each decade. 2/ Overstory removal done this decade.

3/ Commercial thinning done this decade.

4/ Regeneration (final) harvest done during this decade.



Appendix F
References Cited

APPENDIX F

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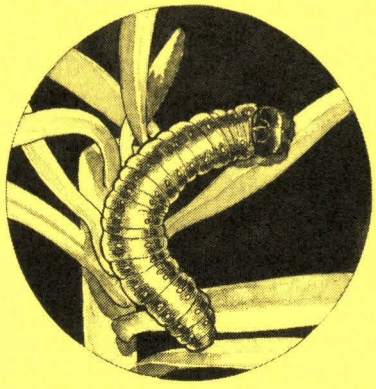

Decision Notice and Finding of No Significant Impact

DECISION NOTICE
AND
FINDING OF NO SIGNIFICANT IMPACT

Western Spruce Budworm Management
in Oregon and Washington
Suppression Projects for 1988

Baker, Clackamas, Grant, Hood River, Jefferson, Malheur,
Umatilla, Union, Wallowa, and Wasco Counties in Oregon

Klickitat, Yakima, Walla Walla, Columbia,
Garfield and Asotin Counties in Wahington

USDA Forest Service

Western spruce budworm, Choristoneura occidentalis, continues to defoliate large acreages of coniferous forest in Oregon and Washington. An analysis of the current situation was done on 2.5 million acres within 21 Analysis Units (AU's). An Environmental Assessment was prepared which documents the analysis and the proposed management alternatives. This document is available for public review at the Forest Supervisors' Offices of the following National Forests: Mt. Hood - Gresham, OR; Malheur - John Day, OR: Wallowa-Whitman - Baker, OR; Umatilla - Pendleton, OR; and in the Ranger District Offices of these Forests.

The alternatives considered were: (A) the no-action alternative which would not take any direct action to reduce budworm populations, and (B) insecticide treatment with Bacillus thuringiensis (B.t.), a biological insecticide.

Over half of the acres analyzed qualified for potential insecticide treatment based on reasons such as projected high timber benefits, protection of visual resources, and responsibilities to adjacent private landowners. Therefore, I have selected, in order of priority, the following areas for potential insecticide treatment in 1988 (Reference Environmental Assessment Appendix D).

1. Selected portions of the Starkey Analysis Unit.
2. Barlow Analysis Unit.
3. Northeast portion of the White River Analysis Unit.
4. The Dalles Analysis Unit.
5. Simcoe Analysis Unit.
6. Mt. Hood Analysis Unit and a portion of the High Rock Analysis Unit.
7. Meacham Analysis Unit.
8. Portions of the Jubilee, Target, and Ruckel Analysis Units.
9. Wilson and Southwest portion of the White River Analysis Unit.
10. Jefferson Analysis Unit.

This priority listing is valid assuming these areas will qualify for treatment based on pre-spray budworm population levels. Actual treatment will also be predicated on the availability of resources necessary to accomplish the job in a quality manner.

The selected units include the maximum acres that can be logistically treated. I have chosen these over other AU's, some of which have higher projected timber benefits, for one or more of the following reasons, depending upon the AU:

a. Length of infestation, and severity of existing and potential damage.

b. To protect existing visual and recreation resource values.

c. To help satisfy private landowner concerns about budworm-caused damage.

d. To ensure the probability of effective treatment.

Many of the units which have a high benefit/cost ratio have had only a few years of defoliation and will not incur substantial irreversible damage from another year of defoliation. Those units not selected for treatment in 1988 will be analyzed again in 1989.

Forest Supervisors on affected National Forests are directed to take appropriate action with regard to the implementation of any mitigating measures identified in the Environmental Assessment, including preparation of an in-depth spill and accident plan and preparation of a project work plan that will identify mitigating and monitoring measures appropriate to each AU. Action will be taken to adequately buffer long-term insect population research plots located within the Meacham, Ruckel, and Starkey AU's. Mitigating measures, as identified by the US Fish and Wildlife Service, for any threatened or endangered species occurring within an AU will be implemented.

I have determined, based on the environmental analysis, that this is not a major Federal action that would significantly affect the quality of the human environment. Thus, an Environmental Impact Statement is not needed. This determination was based on the following:

a. There are no irreversible resource commitments.

b. There are no known cumulative adverse effects and no significant indirect adverse effects.

c. With appropriate mitigating measures, there are no known adverse effects on threatened and endangered species.

d. There will be minor overall effects on wildlife and fisheries.

e. There will be minimal long-term impacts on water resources.

f. There are no known significant effects on public health and safety.